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Carl Murchison

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STUDIES IN CONFIGURAL CONDITIONING V GENERALIZATION AND TRANSPOSITION*

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A. The Problem

Three terms—transfer, generalization, and transposition—have in recent years been used by psychologists to denote the phenomenon that an organism's learning to respond or act in some way to some stimulus or situation may carry over to some other stimulus or situation. Transfer, the oldest term, has come to us mostly from work on skill, memory, and capacity, generalization—from experiments on conditioned reflexes, and transposition, the latest importation, has reached us through the investigations and discussions of the Gestalt psychologists. There seems to be no objection to retaining, with qualifications, all the three terms. One might use *transfer* when referring to complex learning or in general when the *fact* rather than the *process* of the carry-over is emphasized. On the other hand, both *generalization* and *transposition* are more illustrative when the *s-O-r* relation is specific and defined or when in general the mechanism and process rather than the mere act of the carry-over is under consideration. *Generalization* may be employed for carry-overs that are regular along some stimulus continuum in the manner of Pavlov's irradiation of *CR*'s or Thorndike's spread of "*effects*," while *transposition* may cover those cases in which the tested situation is related to the trained situation by virtue of *patterns* or *relations* rather than through *elements* or *constituents*.

In the present series of experiments generalization and transposition were studied in 32 adult human subjects by the conditioned salivary technique Specifically, the subjects formed salivary *CR*'s to patterns of lights and to single lights of these patterns by combining the flashings of these lights with repeated short eating periods After the *CR*'s were formed the colors of the lights were changed, and the transfer effects for both patterns and single lights were

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tested at different stages of conditioned training. The two main questions in mind were: First, How is transfer in single stimuli (generalization) related to transfer in patterns of stimuli (transposition)? Is transposition some sum or product of generalization, as atomistic mechanists might claim, or is the former altogether unpredictable from the latter, as the totalitarian Gestaltists might argue? Second, What is the effect of training upon transposition? We know from the work of Pavlov and others (2, 11) that training greatly restricts the range of generalization. Would its effect be similar in transposition of conditioning, or would it follow here results in discrimination experiments where training as a rule widens rather than narrows the range of transposition? An answer to these questions appeared to be of vast significance as material in synthesizing the two main contemporary currents of explanations: *Conditioning* and *Gestalt*.

B. PROCEDURE

The writer's general salivary *CR* technique with adult human subjects has been described before (14) and will not be further detailed. It consists, first, of measuring salivation by increments in weights of dental cotton rolls (Johnson and Johnson, No. 3, 1.5 x 0.5 in.) inserted under the subjects' tongues for a short period of time, usually one minute. To prevent evaporation, scale-corrosion and absorption, the rolls are weighed in small envelopes and reweighed in the envelopes immediately after the removal of the rolls from the subjects' mouths Since the cotton-in-the-mouth is by no means a totally inactive stimulus, periods of control salivation must always be rotated with experimental periods, but the weighing itself need not be more accurate than to one centigram, milligram accuracies being as a rule a superfluous refinement. Secondly, the technique involves presenting a *series* of stimuli during eating periods of 2-4 minutes and misinforming the subjects about the purpose of the experiment so as to forestall disturbing subjective attitudes and association-sets. Series of stimuli and comparatively long eating periods are used, as misinforming is unsuccessful and association-sets can hardly be averted with the traditional single-conditioned-stimuli-plus-brief-reinforcements procedures. Telling the subjects that the purpose of the experiment is "to study the effect of eye-fatigue upon digestion," with visual stimuli; "the influence of music upon salivation," with to-be-conditioned musical sounds; and diverse imaginary learning and memory problems with verbal and with motor conditioned stimuli, are serviceable "misinforming" techniques

In the special procedure of this study the conditioned stimuli were mostly flashes of small colored electric bulbs, presented in temporal and spatial patterns Specifically, these patterns were· (*a*) alternate single flashes of lights (2.5 volts, ⅜ in diameter) of the same or of different colors following each other at constant or at variable intervals, (*b*) simultaneous flashings of two small lights of the same or of different colors at distance of 0 5, 1, 2, 3, and 4 inches; (*c*) simultaneous flashes of two lights of different colors, sizes, and intensities; (*d*) simultaneous flashes of two large lights (36 c p.) of different colors with one or two small white lights between them; (*e*) simultaneous flashings of four small green lights forming a horizontal line, an oblique line, a triangle, or a quadrilateral; (*f*) simultaneous flashes of eight green lights forming a closed square, an open square, two adjacent open rectangles, and an open hooked square; (*g*) simultaneous flashings of 10 green lights forming a horizontal line, two right angles, one right angle, and nine lights in a horizontal line and one light above the line; (*h*) sounding a bell simultaneously with the flashing of a green light; (*i*) flashing a nonsense syllable simultaneously with the flashing of a green light In all there were 26 different stimuli-patterns. The number of subjects used for each pattern varied from 2 to 16, and each subject was conditioned to 2-4 different patterns. The eating periods—pretzels, tea-sandwiches, lollipops, and chewing gum—were of 2-3 minute duration, in the course of which the stimuli-patterns were intermittently presented 8-60 times. The testing periods for each pattern or single stimulus were of one-minute duration, and an eating-and-observing period plus 2-4 testing periods constituted one complete trial. There were 5-8 complete trials in an experimental session, and 5-8 experimental sessions were made with each subject.[1] The *transfer* tests—both for the single stimuli and for the patterns—were given only once in each experimental session They consisted of substituting blue lights for green lights, yellow lights for red lights, buzzers for bells, and monosyllabic words for nonsense syl-

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[1] The reader is referred to the writer's previous studies of this series for greater detail This study deals only with the transfer data of the series; no special experiments were set for it.

TABLE 1

GENERALIZATION (SINGLE-STIMULI TRANSFER) AND TRANSPOSITION (PATTERN-TRANSFER) OF SALIVARY *CR's* IN 32 ADULT HUMAN SUBJECTS

The Trained Conditioned Stimuli were Red, Green, and White Lights, Bells, and Nonsense Syllables, the Transfer Stimuli were Yellow and Blue Lights, Buzzers, and Monosyllabic Words Each Entry Represents Conditioned Salivation to the Transfer Stimuli Expressed as Percentages of the Mean Conditioned Salivations to the Trained Stimuli

Description of pattern	Kind of transfer	No. of subjects	Per cent of transfer in successive sessions 1	2	3	4	5	6	7	8
Red light following green light and vice versa	Pattern	16	32	63	70	77	79	76		
	Single light		46	50	32	22	20	24		
Lights of same color following each other	Pattern	4	54	50	44	52	36			
	Single		45	52	34	30	24			
Red and green light at 5 in distance	Pattern	2	19	25	37	58	70	43	30	23
	Single		65	52	42	30	34	26	28	24
Lights of same color at .5 in distance	Pattern	2	4	22	18	43	46	50	32	18
	Single		26	64	32	30	16	23	14	10
Red and green light at one in distance	Pattern	2	64	68	75	90	90	78		
	Single		84	67	53	13	22	20		
Red and green light at 2 in. distance	Pattern	8	48	59	63	75	77	79	32	34
	Single		64	62	50	37	32	19	11	8
Lights of same color at 2 in. distance	Pattern	4	35	39	51	49	37	18	23	17
	Single		48	60	45	32	21	16	18	23
Red and green light at 4 in. distance	Pattern	2	42	46	58	61	64	58		
	Single		64	42	40	51	32	30		
Red and green light unequal in intensity	Pattern	2	45	54	76	70	74	78		
	Single		32	68	53	34	32	18		
Green light and sound of bell	Pattern	2	45	53	56	49	42	16		
	Single		87	53	42	20	26	12		
Green light and nonsense syllable	Pattern	2	58	72	89	94	97	86		
	Single		76	62	61	43	22	10		
Large red and green light at 3 in distance	Pattern	2	58	62	68	70	85	94		
	Single		68	60	53	60	62	42		
Same lights with small white light between	Pattern	2	42	68	76	87	96	98		
	Single		50	32	26	19	9	6		
Same lights with two small lights between	Pattern	2	58	78	80	86	88	82		
	Single		34	56	30	24	20	22		

lables. The subjects were college undergraduates, paid by *NYA* 50 cents per hour, and the experiment was conducted in a dimly lighted room, between 3 and 5 o'clock in the afternoon. The "given"

TABLE 2

Generalization (Single-stimuli Transfer) and Transposition (Pattern-transfer) of Salivary *CR*'s in Adult Human Subjects

The Trained Conditioned Stimuli were Spatial Patterns of Green Lights—and Single Lights of these Patterns, the Transfer Stimuli were the Same Patterns with Blue Lights and Single Blue Lights. Each Entry Represents Conditioned Salivation to the Transfer Stimuli Expressed as Percentages of the Mean Conditioned Salivations to the Trained Stimuli, and is a Mean of Two Subjects

Description of pattern	Kind of transfer	Per cent of transfer in successive sessions							
		1	2	3	4	5	6	7	8
Four lights in a horizontal line	Pattern	32	46	51	47	52	27	28	19
	Single	45	32	26	39	19	24	22	10
Four lights in an oblique line	Pattern	22	36	48	56	46	21	19	24
	Single	32	56	42	37	29	30	22	18
Four lights forming a triangle	Pattern	36	49	56	62	66	57	62	45
	Single	43	57	30	22	19	18	12	9
Four lights forming a quadrilateral	Pattern	24	38	49	67	60	62	43	32
	Single	76	45	32	30	24	26	19	11
Eight lights forming a closed square	Pattern	40	48	52	56	62	70	75	76
	Single	50	45	30	23	22	16	19	10
Eight lights forming an open square	Pattern	32	56	68	74	82	88	90	72
	Single	62	54	40	30	23	17	12	10
Eight lights as adjacent open rectangles	Pattern	38	46	69	78	86	94	90	88
	Single	45	62	44	36	30	25	36	14
Eight lights as a hooked square	Pattern	46	68	78	86	90	98	90	96
	Single	35	46	38	34	29	26	17	10
Ten lights in a horizontal line	Pattern	22	30	32	28	34	36	25	22
	Single	52	40	32	24	20	12	14	8
Ten lights forming a right angle	Pattern	25	46	57	56	60	64	58	42
	Single	43	40	32	30	28	27	19	16
Ten lights forming two adjacent right angles	Pattern	26	46	58	64	60	72	78	60
	Single	35	38	23	20	21	25	18	14
Ten lights, 9 in a line and one above the line	Pattern	23	34	38	40	46	48	50	24
	Single	57	68	43	40	26	20	24	17
Means (Tables 1 and 2)	Pattern	38± 4	50± 4	56± 5	64± 5	67± 6	66± 8	52± 8	44± 6
	Single stimulus	52± 3	54± 4	39± 3	34± 4	25± 5	21± 3	19± 4	14± 4

purpose of the experiment was "to study the effect of eye-fatigue upon digestion."

C. Results and Discussion

The results are presented in Tables 1-2. The entries in these tables represent net conditioned salivations—minus control salivations—to the *transfer* stimuli, expressed as percentages of the mean conditioned salivations to the *regular* conditioned stimuli. (The means of the regular conditioned salivations varied from 7 to 28 centigrams per one-minute periods.) They are given for each experimental session and for both component (single-stimuli) and pattern transfer. When the patterns were not only spatial but contained component stimuli that differed in kind from each other, the single-stimuli entries represent the means of the different single components. With the exception of two patterns—the combination of a light and a sound and the lights of different size and intensity—the inter-componental differences, consisting as they did mostly of differences between lights that differed only in color, were negligible. (In the two exceptional patterns, the sound produced *CR*'s of greater magnitude but manifested less transfer; the light of greater intensity, similarly, elicited more conditioning but was unaffected in its proportionate transfer.)

Examining these tables, a number of facts about generalization, transposition, and their relations to each other seem to stand out. First, it is obvious that these results confirm the numerous findings of Pavlov, Beritoff, and their associates (2, 13) that training—not only differential training by the method of contrasts—restricts greatly the amount of generalization, or single-stimuli transfer. On successive experimental sessions, the means of the per cent of generalization to all transfer stimuli were: 52, 54, 39, 34, 25, 21, 19, 14, and there were very few deviations from this tendency in the individual transfer stimuli. The findings also lend some support to the often observed rise in generalization in the early stages of *CR* training (Russian laboratories and Hovland, 5). The mean per cent of generalization was 54 in the second and 52 in the first experimental sessions, and these differences were quite pronounced in 10 of the 26 types conditioned stimuli. The failure of this phenomenon to manifest itself in the remaining 16 *CR*'s may perhaps be attributed to their transfer tests occurring too late in the training and thus missing the initial widening wave of generalization. As it may be remembered, while the experimental sessions of this study consisted only of 5-8 training trials, they actually comprised a greater amount of conditioning, since the conditioned stimuli had been presented 8-60 times during each trial.

The important results of this study are, however, no doubt those that clearly show that transposition—pattern or relations transfer—differs markedly from generalization. Unlike Pavlovian generalization, the range of transposition widens rather than narrows with training and in general its correlation with generalization is inverse. In the first five experimental sessions the *means* of the *transpositions* to all *CR*'s were 38, 50, 56, 64, and 67, and the *rho* between transposition and generalization was —0.69±0.03. True, some drop in transposition was noted in the last three sessions—66, 52, and 44 per cent—but this apparently is due to overtraining and could hardly be held as evidence against the main finding[2] that transposition and generalization are quite distinct and even opposing phenomena, a finding that has recently been corroborated in *CR* experiments with various musical intervals (21) In general, the writer's empirical results cast grave doubts upon attempts to "deduce" transposition in discrimination experiments from generalization (Spence, 23) and to some extent also upon any sheer "logical" deduction of complex learning from simple conditioning (Hull, Lepley, and others). If the mere addition of a red to a green light, with a response and set-up that eliminated largely central or subjective controls, produced such basic differences in the main attributes of conditioning,[3] what can be said of learning complicated by differential motivation, *preparatory reactions, sets, goals, symbolic interferences and facilitations*, and the like? No doubt there are fundamental common factors to all forms of learning, and Pavlov's conditioning or Meyer's "double stimulation" may well be their chief source or archetype But, since there are basic differences as well as similarities, these factors cannot be adequately deduced from a few postulates but must be patiently discovered through experimentation and study of results at each level or form of stimulus, response, and organism organization.

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[2] See Jackson for similar results with overtraining in discriminatory learning of children (9).

[3] For complications in the "laws of conditioning" with compound stimuli in animals see the writer's historical summary of configural conditioning (16); for basic differences in extinction and retention between pattern and single stimulus conditioning, see the paper on "Comparative extinction and retention of pattern and single stimulus conditioning" (20), for relations of transposition to complexity of stimulus pattern, see the article on "Gestalt organization and configural conditioning" (19).

D. SUMMARY AND CONCLUSIONS

1. Generalization (single-stimuli transfer) and transposition (pattern-transfer) were studied in 32 adult human subjects by the conditioned salivary technique. *CR's* were formed to 26 patterns of stimuli and to the component stimuli of the patterns, and the transfer effects of each were tested on 5-8 successive experimental sessions.

2. The two types of transfer were quite distinct and correlated negatively with each other

3. As in the animal experiment of Pavlov, Beritoff, and their associates, training decreased greatly the amount of single-stimulus transfer, but pattern-transfer, on the contrary, increased a great deal upon successive training.

4. There was also some evidence that in the very beginning of the conditioned training there may be a preliminary stage of an increase in single-stimuli transfer, and that after considerable over-training pattern-stimuli transfer may decrease.

5. The distinct differences between single-stimuli and patterns-of-stimuli conditioning found in this study—juxtaposed with similar findings by the writer in other studies and by recent Soviet investigators in animal experiments—suggest the need of studying separately the attributes of conditioning at each level of *s-O-r* organization, and cast doubt upon the value of merely deducing complex learning from a few postulates of simple conditioning.

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PERSONALITY PATTERNS IN REFORMATORY INMATES*

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The addition of the classification system to many state prisons and reformatories is based upon the recognition of the fact that the offender presents not only a legal problem but a psychological problem as well. Experience from this type of work has shown that much can be accomplished toward the rehabilitation of the criminal if the pertinent facts regarding his psychological nature are known to those in charge of the correctional program This leads directly to the problem of a suitable methodology for obtaining these pertinent facts.

Simpson (2) has made an important step in this direction. Using the Thurstone *Personality Schedule,* he made a psychoneurotic inventory of 252 prison inmates. His most important findings were that inmates scored higher on the average than did a control group of college students, and that a reliably larger proportion of inmates was in need of psychiatric attention than of college students.

Simpson's work, however, is open to criticism on several points In the first place, his age range for inmates, 18-48, is considerably in excess of that for students. Obviously there is no control for the elimination of age as a possible factor in the measurement of personality pattern. In the second place, approximately 50 per cent of his inmate population showed records of previous incarceration. Since it is now believed that prison life itself has a distorting effect upon the personality pattern, Simpson's results are invalid to the extent that the factor of previous incarceration has not been corrected for.

Further, Conklin (1) has criticised the use of the total score on the Thurstone *Schedule* as an indicator of the vague something

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[1] The writer is indebted to Mr. Donald T. Griffin, of the Indiana State Welfare Dept, and to the members of the classification staff of the Indiana Reformatory for their generous cooperation in this study.

called neuroticism, since the total score represents the adding together of many questions dealing with widely different personality patterns. Obtaining responses from 164 competently diagnosed pathological cases, he was able to isolate three diagnostic patterns, or question lists, with which it seemed possible to differentiate a merely abnormal personality pattern, a psychotic pattern, and a schizoid pattern. Thus, of the three pattern lists, the abnormal list seems to indicate a trend of the pattern in some abnormal direction, the psychotic list seems to differentiate toward either a cycloid or schizoid pattern, and the schizoid list indicates a pattern that is distinctly different from the cycloid type.

Now it is well known that classification staff members are in need of some device that will single out those inmates that are more acutely in need of their attention. Not only would such a device be useful for detective purposes, but for an indication of the deviational trend as well. This paper is an attempt to emphasize what seems to be a useful technique for the study of personality patterns, and to describe the personality pattern of reformatory inmates more specifically than the term *neurotic* allows.

Technique and Procedure

The writer has recently administered the Thurstone *Personality Schedule* to 115 inmates of the Indiana Reformatory at Pendleton, Indiana. For purposes of securing a greater homogeneity of pattern and one that is more strictly comparable with that of a control group of college students the age range was limited to the years 17-23. Further controls were used in that only first arrested first offenders were examined. It was anticipated that these controls would also eliminate largely the distorting effect of extended prison life and that the results would therefore mirror relatively more of the pre-prison personality pattern.

Honesty in answering the questions was invited by the statements that they were cooperating in a research project of interest to no one but the writer, that names would not be revealed, and that results would not go on the prison records. Motivation was favorable in that the inmates were temporarily free from routine duties, and in that they were in a position to express themselves freely on personal topics. Inmates were examined in groups of 10 to 15 in the presence of a number of the classification staff.

The papers were scored with the Thurstone key and the three diagnostic scoring devices developed by Conklin (1).

RESULTS AND DISCUSSION

The corrected coefficients of reliability obtained by the split-half method for each of the four scorings are as follows: Thurstone, .938; Conklin, Abnormal, .95, Psychotic, .69, and Schizoid, .63

Table 1 presents a summary of the statistical scores obtained from five group types[2] when Conklin's diagnostic scorings are used. With the use of this table one may compare the mean of a given group type with that of any other group type by means of the critical ratio

A comparison of the statistical scores derived from the Thurstone scoring with those of Simpson reveals that inmates selected in the manner of this study score higher on the average. The mean score obtained in this study was 54 48±2 42, and is reliably higher than the Simpson average by a critical ratio of 3.80. When analyzed in terms of their psychological correlates the present data reveal that 14.8 per cent of inmates are needful of psychiatric attention, 20.9 per cent are emotionally maladjusted, 47 8 per cent are average, 13.9 per cent are well adjusted, and 2 6 per cent are exceptionally well adjusted. This represents a general upward shift in score from the per cents given by Simpson, and is particularly noticeable in the two upper categories

These differences suggest that the younger and more naive offender is likely to be the more unstable, perhaps because his social position is that of being accepted neither by the legally free group nor by the more criminally sophisticated group

The description of the personality pattern of reformatory inmates may be accomplished within limits by a comparison of their scores on the three diagnostic lists with the scores of other available group types. Perhaps the best procedure is that of assuming that the inmate group is like one of the other groups, and then examining Table 1 to see if it relates to the remaining groups in the same fashion that this other group does.

Following this procedure, we may first of all assume that the inmate group presents an abnormal pattern If this is true, then

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[2] The writer acknowledges indebtedness to Prof Edmund S Conklin for permission to re-present his data on pathological and student group types

TABLE 1

SUMMARY OF STATISTICAL SCORES FROM FIVE GROUP TYPES

Scoring	Group	Mean	σ_{av}	σ	Group comparisons by critical ratios*			
					P	*M-D*	*S*	*I*
Abnormal	Student	7.45	.58	5.84	3.75+	4.79+	7.06+	5.08+
	Psychoneurotic	12.70	1.28	7.48	0.00	1.00+	1.73+	.65—
	Manic-depressive	14.59	1.38	9.96	1.00—	0.00	.54+	1.86—
	Schizophrene	15.50	.98	8.67	1.73—	.54—	0.00	3.21—
	Inmate	11.77	.63	6.78	.65+	1.86+	3.21+	0.00
Psychotic	Student	5.18	.29	2.99	3.31—	4.17+	5.88+	2.65+
	Psychoneurotic	3.62	.37	2.14	0.00	6.25+	8.01+	5.62+
	Manic-depressive	7.81	.57	4.10	6.25—	0.00	1.04+	2.29—
	Schizophrene	8.59	.50	4.43	8.01—	1.04—	0.00	3.84—
	Inmate	6.32	.32	3.42	5.62—	2.29+	3.84+	0.00
Schizoid	Student	3.93	.24	2.38	.58—	.28+	7.27+	6.10+
	Psychoneurotic	3.68	.36	2.09	0.00	.66+	6.79+	5.45+
	Manic-depressive	4.08	.48	3.46	.66—	0.00	5.19+	3.76+
	Schizophrene	7.35	.41	3.60	6.79—	5.19—	0.00	2.32—
	Inmate	6.19	.29	3.08	5.45—	3.76—	2.32+	0.00

*The columns marked *P*, *M-D*, *S*, and *I* refer to four group types as follows: *P* = psychoneurotic, *M-D* = manic-depressive, *S* = schizophrene, and *I* = inmate. By reading down the columns of critical ratios one may compare the mean of any of the four groups, for any of the three diagnostic scorings, with that of any group indicated in the column at the left of the table. When the plus sign follows the *CR*, it indicates that the mean of the particular group type (*P*, *M-D*, *S*, or *I*) is higher than that of the group with which it is being compared, and vice versa. Thus, e.g., psychoneurotics (*P*) are higher (plus) on the abnormal scoring than students by a critical ratio of 3.75. Similarly, inmates (*I*) are higher (plus) on the schizoid scoring than students by a critical ratio of 6.10. Conversely, inmates (*I*) are lower (minus) than schizophrenes on the abnormal scoring by a critical ratio of 3.21.

we should expect that inmates would score reliably higher on the three lists than college students do. Examination of Table 1 reveals that inmates are reliably higher on abnormal, psychotic, and schizoid scoring lists than students by critical ratios of 5.08, 2.65, and 6.10 respectively.

Since the inmate pattern may now be called abnormal, we may by a similar procedure attempt to describe the pattern more specifically. The available data allow us to make three hypotheses regarding the character of this pattern, viz.: that it is like the psychoneurotic, the manic-depressive, or the schizophrene group.

Assuming first that the inmate group is like the psychoneurotic group (compare Columns P and I, Table 1) we should expect the abnormal list to differentiate them from students, but not from psychoneurotics, manic-depressives, and schizophrenes. The only exception here occurs in the comparison with schizophrenes, in which inmates are reliably lower by a critical ratio of 3.21. On the psychotic scoring list, if the inmates are like the psychoneurotic group, the mean should be reliably lower than that of students, manic-depressives, and schizophrenes, and equal to that of psychoneurotics. However, inmates are reliably higher than students and psychoneurotics by critical ratios of 2.65 and 5.62 respectively. Inmates are lower than manic-depressives and schizophrenes, but the differences are not nearly so great as those found when psychoneurotics are compared with manic-depressives and schizophrenes. Finally, on the schizoid list the inmates should not differ from students, psychoneurotics, and manic-depressives, and should be reliably lower than schizophrenes. However, inmates are reliably higher than students, psychoneurotics, and manic-depressives, and although they are lower than schizophrenes by a critical ratio of 2.32, the difference is not so great as that which is expected. The obvious conclusion to be gained from these comparisons is that inmates are more like the psychotic groups than they are like the psychoneurotics.

Scores from manic-depressive and schizophrene groups are available against which we may check the scores of inmates. If inmates are like the manic-depressive group the mean on the abnormal scoring should be reliably higher than that of students, but not greatly different from those of psychoneurotics, manic-depressives, and schizophrenes. An exception occurs here in that inmates are reliably lower than schizophrenes. On the psychotic list the inmate mean should be reliably higher than those of students and psychoneurotics, but not different from manic-depressives and schizophrenes. However, inmates are lower than manic-depressives and schizophrenes by critical ratios of 2.29 and 3.84 respectively. Finally, on the schizoid list the inmate mean should not differ significantly from those of students, psychoneurotics, and manic-depressives, but should be reliably lower than that of schizophrenes. To the contrary, the inmate mean is reliably higher than those of students, psychoneurotics, and manic-depressives, and differs from the schizophrene mean by a critical ratio of only 2.32. The conclusion that inmates are like the manic-depressive group becomes hardly tenable.

The hypothesis that inmates are like the schizophrene group remains to be examined. If this is tenable the inmate mean on the abnormal scoring should differ significantly from that of students, but not from those of psychoneurotics, manic-depressives, and schizophrenes. The exception is that inmates are reliably lower than schizophrenes. On the psychotic list the inmate mean should be reliably greater than those of students and psychoneurotics, but should not differ significantly from those of manic-depressives and schizophrenes. The expected results occur in the first two cases, but not in the last two. Finally, on the schizoid list the inmate mean should be reliably greater than those of psychoneurotics, manic-depressives, and students, but not reliably different from that of schizophrenes. That these expected results occur can be seen in Table 1 (compare Columns *S* and *I*). Although the inmate-schizophrene difference on the schizoid scoring approaches reliability, the fact remains that the inmate mean is closer to that of schizophrenes than to that of any other group type.

Summarizing the foregoing statistical comparisons, we must conclude that the personality pattern of inmates is significantly abnormal, that it is more like the psychotic than like the psychoneurotic, and that it is more schizoid than cycloid in trend. This does not mean to say, of course, that inmates are largely schizophrene cases. Such a statement is beyond the scope of the diagnostic lists, as Conklin (1, p. 23) clearly points out. Nevertheless, it is significant that 14.8 per cent of inmates have a high enough score to indicate the need for psychiatric attention, and further that 31 per cent score higher than the mean of diagnosed schizophrenes on the schizoid list.

SUMMARY AND CONCLUSIONS

One hundred fifteen first arrested, first offending inmates of the Indiana Reformatory, of the age range 17-23, were engaged to fill out the Thurstone *Personality Schedule* under favorable conditions. Responses were scored with the Thurstone key, and with the abnormal, psychotic, and schizoid diagnostic keys developed by Conklin. Coefficients of reliability by the split-half method for the Thurstone, abnormal, psychotic, and schizoid lists were 938, 95, .69, and .63 respectively. The mean Thurstone score for inmates was found to be reliably greater than that given by Simpson, the upward shift being general rather than specific to a given range.

The results of this investigation seem to warrant the following conclusions:

1. The personality pattern of reformatory inmates is significantly abnormal when compared with that of a control group of college students.
2. The inmate pattern is more like that of the psychotic group than that of the psychoneurotic group, and is more schizoid than cycloid in trend.
3. The diagnostic scorings of the Thurstone *Schedule* developed by Conklin appear useful for psychological work carried on in reformatories and prisons.

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AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF PROLONGED INVERSION OF THE VISUAL FIELD IN THE RHESUS MONKEY (MACACA MULATTA)*[1]

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A. INTRODUCTION

The perception of spatial loci and attributes of stimulating objects represents a basic form of organismic behavior The experimental psychologist, dissatisfied with mere verbal speculation regarding the nature and conditions of such behavior, has attacked the problem empirically from various angles. The writer has elsewhere (15) outlined the more outstanding empirical approaches which have been made to the problem of spatial localization.

Experiments on normal adult human subjects have not greatly enhanced our knowledge concerning the development of spatial localization. As Ewert (10) has pointed out, this has been in part owing to the fact that perceptual phenomena have frequently been so shrouded in vague phenomenological terms as to make their existence mere artifacts.

The complex nature of such perceptual behavior has also tended to obscure its origin, development and underlying mechanism; spatial localization develops so slowly in the human organism and is so interrelated with maturational processes, spontaneous involuntary

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[2] The writer is indebted to a number of colleagues in various fields for their interest and cooperation in the present experiment. In particular, acknowledgment is made to Prof C. J. Warden of the Laboratory of Comparative Psychology, Columbia University, for placing the complete facilities of the laboratory at the writer's disposal; to Dr Anne Anastasi of the Department of Psychology, Queens College, for help in the collection and interpretation of data, to Dr. S. E. Barrera, Research Associate, New York Psychiatric Institute and Hospital for various stimulating suggestions and concrete methodological aids; and to Mr. K. F. Larkin, Optician, Institute of Ophthalmology, Presbyterian Hospital, New York City, for invaluable aid in constructing the reversing spectacles.

responses, and various orders of conditioned reactions as to resist careful analysis in the normal adult human subject.

For this reason, other approaches have been sought. Resort has frequently been made to the use of other than normal adult human subjects, i.e., to infrahuman animals, human infants, human subjects reared in widely different cultures, psychopathological human subjects, subjects suffering from permanent central or peripheral anatomico-physiological defects, subjects who have recovered from congenital sensory deficiency, or those who have received successful therapy in cases of sensory defects. An even more fruitful approach, however, has been the experimental production of temporary abnormalities in the sensori-motor behavior of normal adult human subjects, yielding data from immediate as well as from prolonged temporary sensory disorientation, both when such disorientation is primarily intra-sensory or limited to a single modality, and when it is inter-sensory and sensori-motor. For a complete summary of these various approaches, the reader is referred to Carr (7), Ewert (9, 10, 11), and Foley (15).

B. Historical Background

The purpose of the present investigation was to determine experimentally the effect of inverted retinal stimulation upon spatially coordinated behavior, when complete retinal inversion is present in all visual stimulation over an extended period of time. Before proceeding to the present experiment, let us briefly indicate the more relevant previous investigations which serve as a background for the derivation of the immediate problem. We shall consider only experiments limited to the visual modality,[8] and we shall arbitrarily exclude as irrelevant those investigations dealing with congenitally blind subjects, monocularly or binocularly blindfolded subjects, and subjects born blind but subsequently recovering vision by an operation for the removal of congenital cataracts. In fact, almost all of the investigations to be reported have employed a refractive device (prisms, mirror) either to correct disturbances in space localization in cases of visual defects or to produce experimentally some form of visual distortion or oculo-motor disorientation

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[8] The reader's attention is called to similar experiments in audition, in which pseudophones, sound reflectors, and electric microphones have been used to produce binaural transposition of sound. Cf. Thompson (40), Urbantschitsch (41), Von Hornbostel and Wertheimer (43), Willey, Inglis and Pearce (47), and Young (52, 53, 54).

Several investigators, such as Hartridge (18), Landholt (24), Stevens (32), and Swanzy (39) have reported attempts to correct *strabismus* by means of hygienic, orthoptic, surgical, and refractive techniques. In attempts to correct disturbances in space localization in *homonym hemianoptic* patients, there has likewise developed a practical therapy which makes use of reflecting prisms or mirrors to replenish the eyes with the necessary stimulation for normal ocular activity Attempts have been made to reflect the visual field, which in hemianopsia falls upon the blind area, so that it again falls upon the normal visual region Perhaps the first of such attempts to correct disturbances in orientation by the use of prisms was made by Best (1), similar techniques being employed by Braunschweig (4), Igersheimer (22), and Strebel (38).

Best (1) prepared prism-spectacles which reflected the visual field 10° toward the blind side. Thus objects, which would fall 5° into the blind area, were focused upon the normal visual area Although Best does not report complete fusion of the prismatically projected field with the normal field, he does report an essential improvement in orientation as a result of wearing these spectacles by one of his hemianoptic patients.

A similar technique is reported by Strebel (38), who placed a 7° prism, which deflected the field 3.5°, before the eyes of an hemianoptic patient. Strebel likewise found an improvement in oculo-motor adaptation after prolonged use of the spectacles He concludes that the optical effect of the deviated visual field is accompanied by a motor-set reaction, the two being mutually compensatory in the reharmonization of the conflicting sensory guidance which the spectacles at first produce As Ewert (11) has pointed out, this view is in agreement with his interpretation of re-orientation (9)

Braunschweig (4) employed prism-spectacles identical with those of Strebel (38), and verified the latter's results Braunschweig is of the opinion that the helpful effect of such prism-spectacles in achieving re-orientation is in part a function of reduced fatigue contingent upon decreased extensity of the blind area.

Igersheimer (22) subsequently introduced mirror-spectacles which, by means of mirror-prisms, reflected the entire visual field falling upon the blind area of total homonym hemianopsia so as to focus it upon the normal retinal area The reflected visual field, "projected" in accordance with the laws of bi-retinal inversion, thus harmonized and overlapped with the corresponding visual field of the other eye, resulting in two non-identical visual fields which had to be coördinated with practice. Reharmonization would thus consist of an altered transposition of retinal points in the prismatically stimulated eye in such a fashion that the two spatial fields would become congruous. Although complete congruity was not achieved, Igersheimer reports great improvement in localization with practice, both for normal and hemianoptic subjects wearing such mirror-spectacles over a period of time.

The theoretical implications of such re-orientation as a result of wearing prism- and mirror-spectacles have been discussed by Ewert (11), Metzger (26), and Wilbrand and Saenger (46).

Wundt (51) was perhaps the first psychologist to introduce experiments on distorted vision to test nativistic theory of space perception. He states (51, p. 514):

> Let the experimenter have a pair of prismatic spectacles made, whose angle of refraction, for the purpose of avoiding disturbing color effects, does not exceed 5 or 6 degrees. When looked at through such a pair of glasses, contours with straight lines appear bent, plane surfaces arched, and complicated views correspondingly distorted. If a person can make up his mind to wear such a pair of spectacles continually, these distortions disappear in a very few days . . . Inasmuch as the image on the retina in this case (i.e., during distorted vision) remains the same, this elimination of the metamorphopsia can hardly be ascribed to anything else than an adaptation of the elements of the retina to the new condition of vision.

In an experiment conducted simultaneously at Yale and Toronto, with similar results, Bott, Brown and Cohen (3) investigated the educability of binocular motor patterns.

Prisms were so arranged that the eyes had to diverge vertically in order to achieve binocular fusion of a horizontal line on a white background. Three threshold values were determined: (*a*) break threshold—the angular distance at which fixation was lost as the fields were moved apart, (*b*) make threshold—the angular distance at which fusion was obtained as the fields were moved together, and (*c*) seek threshold—the angular distance at which divergence of the eyes was maintained if the fields were moved apart and held stationary just beyond the point at which fusion was lost. Practice effects were obtained, the absolute values and rates of improvement for the three thresholds ranking in the following ascending order. seek, make, break. The break threshold improved with practice slightly in excess of 2°.

In an experiment on adaptation, after-effect and contrast in the perception of curved lines, Gibson (17) likewise employed prisms to distort the visual field, with subsequent adaptation to such prismatically induced metamorphopsia.

The subjects wore a pair of prisms shifting the visual field approximately 15° to the right. One series of 8 experiments dealt with an examination of the phenomenal bending of vertical straight lines into curves convex to the left, the horizontal components of the figures remaining undistorted. During an hour's observation "a curved line becomes phenomenally less curved than it was at the beginning of the period, and at the end of the period an objectively straight line will seem curved in the opposite direction. This fact holds whether the curvature is actually in the object, or is induced by the distorting effect of the prisms."

Gibson also studied adaptation to prism curvature with 10-minute inspection period, the contrast phenomenon, adaptation to curvature in kinesthetic perception, negative after-effect with a bent line instead of a curved line, limitation of the after-effect to the stimulated area of the visual field, and the transfer of the after-effect to the corresponding area of the other eye. The results indicated that the adaptation effect and the negative after-effect were of the same degree of magnitude, that both simultaneous and successive contrast could be demonstrated and that both these effects occurred for kinesthetic as well as for visual perception. The essential condition for adaptation and after-effect seemed not to be mere curvature of line, but departure from rectangularity, since the phenomena appeared as well on fixating an obtuse angle. The negative after-effect of curvature (i e., bending in the opposite direction) was rather closely limited to the specific area of the visual field previously occupied by the stimulus line When a number of curved lines were fixated, adaptation and after-effect could be correspondingly induced simultaneously in different parts of the field. The negative after-effect showed itself in the corresponding area of the other eye when only one eye had undergone adaptation, the effect being less in the unstimulated eye.

It is important to note that the experiments of Wundt (51) and Gibson (17) are basically concerned with adaptation to prismatically induced metamorphopsia. This type of readaptation has been termed *intra-sensory* by Ewert (10, 11) and Foley (15), since the distortion effects are primarily limited to a single (visual) modality.

Experiments on adaptation to experimentally produced *inter-sensori-motor* disorientation have been performed by Wooster (50), Brown (5), Stratton (33, 34, 35, 36), Ewert (9), and Peterson (30). Let us briefly summarize the chief features of each of such investigations, beginning with the original work of Stratton.

Stratton (40, 41, 42), in 1896-1897, conducted two experiments on vision without inversion of the retinal image. As subject, he wore a monocular system of 2 double-convex lenses, which gave a field of natural magnification, displaced point to point 180° from its normal position, and reported to be 45° in size.[1] The lenses were mounted in a short adjustable tube which was in turn mounted in a plaster cast which fitted the head snugly. The left or unstimulated eye was blindfolded. This apparatus was worn continuously, except during sleeping hours when the eyes were carefully blindfolded, first for three days, or 21½ hours of active visual inversion, and then again for eight days, or 87 waking hours of inversion. Data in the form of introspective notes were recorded daily.

At first there was a general conflict between the immediate visual behavior and old spatial habits. Since there was complete inversion of the visual field, adaptive responses were invariably incorrect when guided by vision, and a process of trial and error exploration was necessary to discover the location of the object. There was no immediate reconstruction of the new visual orientation to agree with the orientation of such other modalities as touch and hearing. During head and body movements, Stratton experienced exaggerated movements of objects, resulting in giddiness and nausea. Adaptive motor responses to visual cues were invariably wrong during the early periods of inversion. Motor responses to tactual and auditory stimuli were successful when vision was excluded. The giddiness and nausea disappeared in time, however, and the conflicting localizing responses finally disappeared with practice.[5] When the lenses were removed, the newly acquired space habits persisted to the extent that adaptive movements to objects were again wrong when guided by vision, but readaptation to normal oculo-motor conditions was quickly achieved.

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[1] Stratton's monocular field, reported to be 45° in size, was doubtless considerably smaller. Ewert's binocular field (9), achieved with the best technical aid, was approximately 34.5°, and the computed monocular field in the present experiment (cf. also 16) was slightly in excess of 30°. Stratton does not report the focal length of his lenses. Ewert has elsewhere (10, pp. 535-540) discussed the nature and function of the lens system used for inversion experiments.

Stratton interprets his results in terms of the experiential correspondence of local signs, resulting in a reharmonization of sense data from vision and other modalities, regardless of the position of the retinal image. He concludes (35, pp. 475-476):

> The experiment clearly shows that an object need not appear in any particular position in the visual field in order to admit of a union or identification of the tactual and visual perceptions of the object. The visual position which any tactual experience suggests . . . is determined, not by some fundamental and immutable relation of tactual and visual "spaces," but by the mere fact that we have constantly seen the object there when we have had that particular touch-

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[5] Stratton's primary interest seems to have been in testing various theories of space perception (especially the projection and eye-movement theories) as well as in the problem of inversion of the retinal image as related to upright vision. His introspective data on the latter problem (33, 34, 35, 36) are extremely ambiguous, and have been variously interpreted by different writers. Some [e.g., Carr (6, 7), Woodworth (48), etc.] have contended that complete intra-sensory as well as inter-sensory and motor adaptation to inversion would occur with prolonged practice, whereas others [e.g., Ewert (9, 10, 11), Higginson (19), Woodworth (49), etc.] have interpreted Stratton's results to indicate improvement with practice in inter-sensori-motor activity under conditions of prolonged visual inversion, but without a change in the intra-sensory experience of inversion other than a decrease in the frequency of attention to this phenomenon, such a lapse of attention creating an *illusion* of normalcy or sensory re-inversion which, however, disappears on closer scrutiny of the visual field. Thus Woodworth (48, p. 401), for example, reports that things eventually "looked right side up again", whereas he later (49, p. 386), after reading some of the writer's correspondence with Stratton, states that although motor readaptation was achieved with practice, "the field of view still did not appear right side up." Conflicting interpretations of this phase of Stratton's results will be found in various elementary textbooks in general psychology, as well as in the more technical discussions of Carr (7), and Ewert (9, 10, 11). Higginson (19) has recently called attention to certain of these differences in interpretation of Stratton's results.

> experience. . . . The inverted position of the retinal image is, therefore, not essential to "upright vision," for it is not essential to a harmony between touch and sight, which, in the final analysis, is the real meaning of upright vision

Wooster (50), in a study on "certain factors in the development of a new spatial coördination," investigated the "relative efficacy of the receptors to various sensory modes of reaction, such as sight, touch, and hearing, in the building up of a new space habit" (50, p. 1). A total of 72 subjects were used in the main experiments, wearing a system of prismatic lenses which produced an angular deviation of 21° in the visual field. The lenses were worn 20 minutes each day. The subjects were periodically tested on a specially constructed apparatus which necessitated the execution of various manual localizing movements both inside and outside of the visual field. Such behavior was observed under conditions in which either visual, auditory, or various combinations of these stimuli were obtained from a set of buzzers.

Under these conditions, Wooster found in general a rapid adaptation to the distortion conditions. There was a gradual and progressive tendency to overcome the large initial errors in localization. No readjustment to the changed visual situation occurred until definite reaching movements were made while the eye was fixated on the visual object, thus indicating the importance of the motor component in the development of the new spatial reorientation. Sound was relatively unimportant in contributing to the formation of the new spatial habits, whereas the combined factors of kinesthesis and contact were found to be essential. Visual perception of the amount of error served as the most important single sensory factor in the development of the new habit. The newly acquired space habits persisted for a period of from 1 to 2 years. The new coördination was not merely specific to the particular conditions of its formation, but persisted when the experimental conditions were changed, indicating a general transfer of training Individual differences were found in the extent to which various sensory factors contributed to the formation of the new spatial coördination. It was concluded that the new coördination was founded on a purely sensori-motor basis, Wooster stating (50, p. 91): "The process of forming the new habit seems to consist largely in the association of visual and tactual stimuli with kinesthetic stimuli involved in the localizing movements"

Brown (5) investigated the perception of depth with disoriented vision, endeavoring to determine whether depth perception is an acquirable function. His apparatus for visual disorientation consisted of a pair of goggles containing right-angle prisms which were fixed in tubes. The prisms could be rotated, thus permitting of any degree of disorientation up to 360° or complete inversion. The visual field was 10° in diameter. The effects of periodic (non-continuous) disorientation at 75° were studied in detail with four subjects, and at certain other angular disorientations less fully with another subject. Disorientation was continuous with only one subject, in which case the goggles, displacing the visual field 75°, were worn continuously, except for short rests and during sleep, for six days. Introspective reports were obtained periodically from the latter subject. The other four subjects wore the goggles when performing certain manual-visual exercises, including reactions on a depth re-education apparatus, steadiness tests, star-blanks for pencil drawing, and pursuit pendulum. Limens of depth perception were obtained under a variety of disorientation conditions before and after practice.

It was concluded (5, p. 144) that disorientation of the binocular visual field decreases the ability to perceive immediate depth as judged by perceptual limens and by overt performance. The loss of depth varied directly with the amount of disorientation. Practice appeared to improve depth perception under distortion conditions, but the evidence was not conclusive. Individual differences were found, both in the amount of loss and of recovery of depth with disorientation. Both introspective and objective evidence indicated that adaptation to the experience of visual disorientation increased continuously as a result of practice.

Undoubtedly the most extensive and best controlled experiment on the effect of inverted retinal stimulation was that conducted by Ewert (9) and published in 1930. The inversion apparatus consisted of a pair of threaded (adjustable) tubes, supported in front of the eyes by a light head-frame, each tube containing three lenses which rotated the visual field 180°. Inversion was obtained by viewing with a negative eyepiece lens system the image formed by a chromatic objective lens of 51 mm. focus. The monocular field of view was estimated at 31°, and the binocular field at approximately 34.5°. The entire framework of the apparatus, including the headgear, was made of aluminum, the complete apparatus weighing 6½ ounces. Extraneous light was shut off by means of a black velvet mask. Three subjects wore the apparatus without the lenses during preliminary experiments of 19, 14, and 10 days' duration, respectively, and then for 14 consecutive days of visual inversion, during which time systematic and detailed study was made of disturbances in tactual, auditory, and visual localization by means of a daily battery of objective tests. The results are reported separately according to stimulus modality.

Tactual localization was studied in an area, 7 x 6 cm., shaved and marked off on the hand, the subject being instructed to touch the point stimulated by *E*'s pencil. Whereas normal vision increased the accuracy of tactual localization, inverted vision decreased the accuracy and brought about complete inversion of the directional tendency in the errors of localization. Although inverted vision was a "distraction" to normal localization, with practice the subject learned to point to the visible area which corresponded to the actual spot touched. There was no evidence that the tactual area would shift to the disoriented visual spot. Retinal-motor habits were reorganized so as to conform to the old touch and the new vision. Learning was of the trial and error type with gradual elimination of errors, and was facilitated by instruction and knowledge. Upon removal of the lenses, 2 of the 3 subjects experienced interference effects.

Auditory localization was studied by verbal or manual localizing responses to a buzzer stimulus presented on one of sixteen 6-inch squares directly in front of the subject in the binocular field. With eyes closed, sound localizations were not disturbed by the coordinations established during inverted vision. There was no tendency for the purely auditory localizations to swing into line with the new visual space localizations. With eyes open, an incongruity between visual and auditory localizations was experienced, vision being a "powerful distraction" to sound localization. There were displacements of the phantom both across the median and horizontal planes for all subjects. With instruction to "localize the sound," inverted vision ceased to be an effective distraction, and normal auditory localizations resulted. Thus visual dominance was not an inevitable result of visual-auditory disorientation; instruction or *Aufgabe* was important. When the buzzer was presented behind a cloth screen, localizations were unreliable and showed marked individual differences. Ewert attributes the diffculty to a conflict in bodily movement tendencies. To control "knowledge," two buzzers were presented simultaneously, one buzzer corresponding to the actual position of the source in normal space and the other to its apparent position in inverted space. Under these conditions, localization was about the same preceding, during, and following disorientation The results thus indicate that without visual distraction sound localization is relatively accurate. There was no transfer effect from previous situations in which vision was a distraction When the two buzzers were placed in asymmetrical positions, vision greatly disturbed sound localizations.

Visual localization was studied by presenting a stimulus object in the visual field Pointing localizations with the finger indicated an initial interference effect, which was overcome by the twelfth day of practice. Pointing localizations of the foot to squares marked off on the floor indicated similar disturbance effects which were corrected by 13 days of practice Card sorting also showed an initial interference effect with disoriented vision. In all these cases practice reduced the disturbance, the readaptation curves being typical of motor learning Among other visual results was the appearance, immediately upon assuming and immediately after disorientation, of a "swimming illusion"—the subjects behaving as though the movements of visual stimuli were abnormally rapid. Special experiments indicated the presence of a pseudoscopic effect in distance estimation. There was no significant transference of localizing ability in the inverted visual field to such ability outside of the inverted field.

In a more recent and unpublished study,* Peterson (30) repeated Stratton's experiments with himself as subject. He wore the inversion apparatus previously used by Ewert (9) and followed a behavior routine identical with that of Stratton (33, 35) The apparatus was worn "about three times as long as Stratton wore his" [cf Ewert (10, p 527)], and negative results similar to those of Ewert were obtained

C. The Present Experiment

A critical survey of the literature on distorted vision shows considerable diversity of interpretation of experimental results. These differences may be explained in part, as Ewert (10) points out, on the basis of the failure of previous writers to distinguish between intra-sensory distortion effects, or adaptation to prismatically induced metamorphopsia, and inter-sensori-motor adaptation It is to this second type of interference and adaptation that the problem of upright vision belongs. Ewert (10, pp. 543-544) has maintained that

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> A confusion of the two types has led to the belief that continuous practice would ultimately result in complete adaptation so that objects in the visual field would again be seen as upright with reference to the body. However, it has been shown that the "feeling of normalcy" in the visual field following a period of continuous inversion, is merely an illusion resulting from a lapse of attention to the experience of inversion The illusion is further attributable to the fact that the pattern of a seen object is not altered by the inverting lenses.

Higginson (19) has recently pointed out the various interpretations of results on visual inversion, and has shown that such differences are even to be found in various elementary textbooks. Many of these differences are doubtless due to the uncertainty and ambiguity of Stratton's introspective reports, to his strong emphasis on mental attitudes, to the lack of quantitative data, and to the tangle of fact and theory. Indeed it is difficult to know just what Stratton did actually find. Ewert (9, p. 187) has also pointed out that Stratton, in taking notes each day, relied upon previous kinaesthetic-motor habits to guide his pencil and thus kept on reinstating old habits

Ewert's results (9), however, as well as the subsequent unpublished results of Peterson (30), are not free from speculative criticism. Bills (2, p. 128) has pointed out that Ewert's experiment was limited to the laboratory situation, with no opportunity for intimate reaction with the environment as in Stratton's experiment. Moreover, Ewert imposed auditory localization tests on the subject, which would tend to disrupt the unity of visual and auditory experience. If localizing reactions are conditioned to language behavior, furthermore, as Ewert's own work has shown, it would seem that linguistic cues, unaltered during visual inversion, might serve to reinstate previous spatial orientation, especially in a sophisticated subject. There is also, of course, the possibility that the experiment was not continued long enough for complete sensori-motor readaptation to take place, or that the original conditioned orientation was so basic that reconditioning to new cues was virtually impossible Finally, it should be pointed out that in any case, regardless of the empirical or non-empirical nature of perceptual space, there is a need for knowledge of basic mechanisms if scientific formulation is to be achieved

The present experiment represents an attempt to combine certain of the approaches described elsewhere (Foley, 15) by applying a direct experimental method, similar to that of Stratton (33, 34, 35), Brown (5), Wooster (50), Ewert (9), and Peterson (30), to an animal subject The disadvantage of such an experiment is that the subject's verbal report is lacking, but it should be noted that this may actually prove advantageous, since the subject is unsophisticated and hence does not anticipate. Ewert's statement (10, p. 522) that animal data "yield only inferential information for human orientation" betrays an anthropomorphic rather than basic scientific interest [cf, Foley (13)] The animal set-up has certain additional advantages which may be capitalized in future work. Visual inversion could be begun at birth, and could, with proper facilities, be continued indefinitely. Stimulational factors in the reactional biography of the subject could be far more rigidly controlled than in the human experiment Nor should we omit the possibility of investigating physiological correlates by means of surgical techniques.

The present experiment, although designed to secure data on sensori-motor readaptation to inverted vision, was in part a preliminary experiment to test the feasibility of such work on the animal subject Could the various practical obstacles associated with the forced wearing of reversing lenses in animals such as the monkey be overcome? In so far as the experiment was carried to successful completion, this question can be answered in the affirmative.

1. *The Subject*

The subject in the present investigation was an adult female rhesus monkey (*Macaca mulatta*), a member of the primate colony at the Columbia Laboratory of Comparative Psychology in New York City. The animal was purchased from a New York animal dealer and arrived at the Laboratories in December, 1930. At the time of purchase she was immature (preadolescent), her age being estimated at almost four years. Most of the data in the present experiment were obtained during June, 1936, when the subject was approximately nine years old. The animal was housed throughout the year in the primate quarters of the Laboratory, fed according to the standardized Columbia Dietary and Feeding Schedule for Monkeys [cf Foley (12, p. 53)], and exercised daily in the runways, receiving a period of Sunlamp stimulation each morning. She remained vigorous and healthy throughout.

When first obtained in 1930, the animal showed no signs of former handling. She was subjected to the standardized adaptation routine in use at the Laboratory, and subsequently served as a subject in experiments on the Jenkins problem box, delayed reaction, motivation (by means of the Columbia obstruction method), imitation, brightness discrimination, and brightness constancy—the latter two experiments using a modification of the Yerkes-Watson discrimination apparatus. The subject was thus exceedingly docile and tractable, an essential requirement in the present experiment.

The selection of the rhesus monkey (*Macaca mulatta*) for such an experiment was determined in part by its availability and adaptability to laboratory routine and in part by its morphological characteristics, the gross anatomy and physiological function of the macaque eye being very similar to those of the human.

2. *Apparatus and Procedure*

The *optical system* used to achieve inversion was similar to that used by Ewert (9), which represented technical improvements upon the apparatus originally employed by Stratton (33, 35) for prolonged inversion experiments. The system consisted essentially of a pair of inverting unit magnification telescopic spectacles. The lenses were mounted in aluminum tubes 20 mm. in diameter, the tubes being threaded securely into the brass bushings of an aluminum mask, hammered to conform precisely to the contours of the animal's face Breathing was unobstructed. The mask was held in place by a leather headgear fastened with straps and surgical adhesive, so that no light could reach the eyes except through the lenses. In order to accustom the animal to the mask and in order to be certain that the behavior during actual inversion could in no way be attributed to the mere presence of the mask and supporting headgear, a pair of empty aluminum tubes was made which could be inserted in the mask in place of the lenses These tubes, comparable in length and diameter to those containing the lenses, were so diaphragmed as to give a visual field identical in size with that obtaining under conditions of inversion

The question of weight being of considerable importance, the telescope and blank tubes, as well as the mask itself, were constructed of aluminum, being made as thin as possible consistent with the requisite sturdiness. Brass bushings were imperative, since the activity of the animal in its efforts to dislodge the headgear required an unusually sturdy mounting The total length of the tubes was 75 mm, so that a sudden turn of the animal's head when near the floor or any solid object would have loosened the tubes unless they were substantially mounted The entire apparatus, including the headgear, weighed 130 grams

A major mechanical problem was the very narrow interpupillary distance of the monkey as well as the difficulty in measuring it accurately, since the animal repeatedly fixated on the ruler used for measuring rather than on a remote fixation point. The required *P D* was found, after checking over a series of measurements, to be 28 mm. The fixation distance, determined from the reach of the animal in grasping and manipulating objects, was fixed at 16 inches. The extremely narrow *P D* together with the need for convergence at the selected distance required that the telescope tubes be set very close together at their distal end and that the diameter of the eye lens in each tube be made very small to clear the nose.

The optical system used for inversion was a simple astronomical telescope, consisting of an objective of 21.8 mm *E F.* and 21 0 mm. diameter, together with the optics of a Kellner eyepiece which consist of a biconvex field lens of 26.2 *E F* and 17 0 mm. diameter and an eye lens in the form of an achromatic doublet of 9 0 mm. *E F.* and 10.0 mm diameter. The two lenses of the ocular were mounted with an overall separation of 33 0 mm. and since this is a positive eyepiece with its focal plane lying some millimeters in front of the field lens, the latter is separated from the objective by this distance plus the *E.F.* distance of the latter, or approximately 42 mm when focused for the required distance of 16 inches. A slight saving in total length could have been made by the use of a negative *E.P.* of the Huyghenian type, but the achromatic and orthoscopic performance and somewhat larger field of the Kellner were considered as more than compensating advantages. The total length of the telescope was approximately 75 mm

The ocular was mounted as a unit in a separate tube which was threaded to the objective tube with a long fine thread for focusing. Each telescope was prefocused and lined up for convergence in fixed form, since no provision for varying object distances was feasible. The computed value of the width of field for each telescope was slightly in excess of 30°, and after assembly the observed field for the human eye was found to be approximately 11 inches in a plane at 16 inches distance; binocularly this would give a field somewhat larger. The computed magnification was unity and this again checked almost exactly at the required distance. Inversion of the image is, of course, a characteristic of this type of telescope, so that so far as could be determined all requirements were fulfilled both from theoretical needs and practical tests.

No data could be obtained on the optical constants of the eye of this type of monkey. Gross observation of specimens, however, revealed the eyeball to be somewhat smaller than that of man, although the difference is slight. Fortunately no great error is likely in setting up with the human eye a telescope for use by the monkey, since emergent rays at the ocular are nearly parallel, i.e., objects seen through the telescope are seen as if at infinity. The best, and in fact the only check on the results obtained by the monkey, must come from the reactions of the latter to visual stimuli.

Certain *characteristics of such inversion lenses* might be mentioned at this point. The visual field is distorted 180° in both vertical and horizontal dimensions. Eye-body movements, with reference to an external object, are thus affected in all directions, and the total visual pattern is involved in all localizations. Ocularly-induced eye movements with reference to the perceived object are reversed, resulting in an antagonism or interference between these and eye movements evoked through the vestibular mechanism, through excitation of bodily muscles, and voluntarily—through verbal or conceptual conditioning, which are initiated as in normal vision. There is no structural disruption of the pattern of a seen object, the intrinsic spatial pattern characteristics of a perceived object retain their relative properties. Finally, it should be noted that since perception of locality, distance, and depth are largely dependent upon convergence, accommodation, retinal disparity, and other psycho-physiological factors, considerable interference in spatial orientation will result, since during lenticular inversion a number of these factors are reversed. Thus, for example, the lenses produce a pseudoscopic effect, near objects appearing distant, and vice versa.

Preliminary experimentation was begun in November, 1934, when the subject was first placed in the new type of restraining apparatus which had been especially devised for the experiment Other tentative methods for preventing the animal from loosening the mask and lens system, such as the use of a padded cage, gloves, etc , had proved impracticable. This apparatus, which has been described in detail elsewhere (14), was designed to retain the monkey in as near normal or "sitting" position as possible, and consisted of two essential parts: (*a*) a chair, with restraining devices for the body and lower extremities, and (*b*) a head-holder, designed to keep the head rigid and motionless The latter was so constructed that when the arc encasing the head was released, the head, held only by the encircling neck ring, was free to rotate from side to side. In fact, the entire restraining apparatus could be adjusted to allow various types and degrees of movement.

When the subject had become adapted to the restraining apparatus and when all traces of tonic immobility had disappeared (cf. 16), a *training series* was instituted, involving the use of a specially designed discrimination apparatus which, it was hoped, might yield objective data regarding the perceived location of a stimulus object in the visual field The apparatus, which need not be described here in detail, consisted essentially of a black panel containing eight stimulus lights and corresponding food-stall apertures, spaced along the vertical, horizontal, and two oblique meridians at maximal distances apart but yet within the subject's lenticular field A central fixation point was lighted continually. The entire panel was set in grooves so that it could be moved away from the subject, the appropriate randomly selected box baited and its respective light-aperture illuminated, and the panel moved up again to within 16 inches of the subject incident to a reaching response for the food. By January, 1935, the light-food association was well established, the subject almost invariably reaching for food from the lighted one of the eight food-stall apertures.[6] This training was continued until

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[6] Other data available, in addition to the direction and degree of error, included reaction time and hand employed in reaching

February, 1935, when it was discontinued until June 1, 1936, at which time it was resumed and continued daily until the lenses were placed on the subject at 2:00 P.M. on June 23, 1936. The subject, emotionally disturbed, then refused completely to react in the apparatus. Observations were made in the form of detailed *protocols* and by *cinematography*.

The reversing lenses were placed on the subject at 2:00 P.M. June 27, 1936, and were worn continually for a period of exactly seven days, or 168 hours. The subject was at first necessarily restrained in the special chair and head-holder, being removed for periods of massage, exercise, and observation. The restraint was decreased as the monkey became adapted to the situation, the aim always being to allow the animal a maximum of freedom and movement without too great a risk of displacing or damaging the lenses. Although the chair was used throughout the experiment, only the waist-band was necessarily employed at times during the later days of inversion, the arm and leg bands being loosely attached at night so that the extremities were free to move although prevented from reaching the lenses.

Protocol notations on general spontaneous behavior were taken at half-hour intervals from 7.00 A.M. until midnight. These were supplemented by data gathered during the periods of exercise and of experimental observation, showing postural and locomotor behavior, reaching responses to food and to other objects presented in various portions of the visual field, auditory "localizing" responses, sensori-motor coördination, etc. Certain of the more pronounced reactions were recorded cinematographically both for normal speed and slow motion projection.

The lenses were removed at 2:00 P.M., June 30, 1936, and similar observations were made during the post-inversion period.

3. *Results*

The results can best be presented by briefly summarizing the significant protocol notations for each of the eight days of lenticular[7] inversion and for the immediately succeeding post-inversion period.

a First Day: Tuesday, June 23, 1936. The immediate effect

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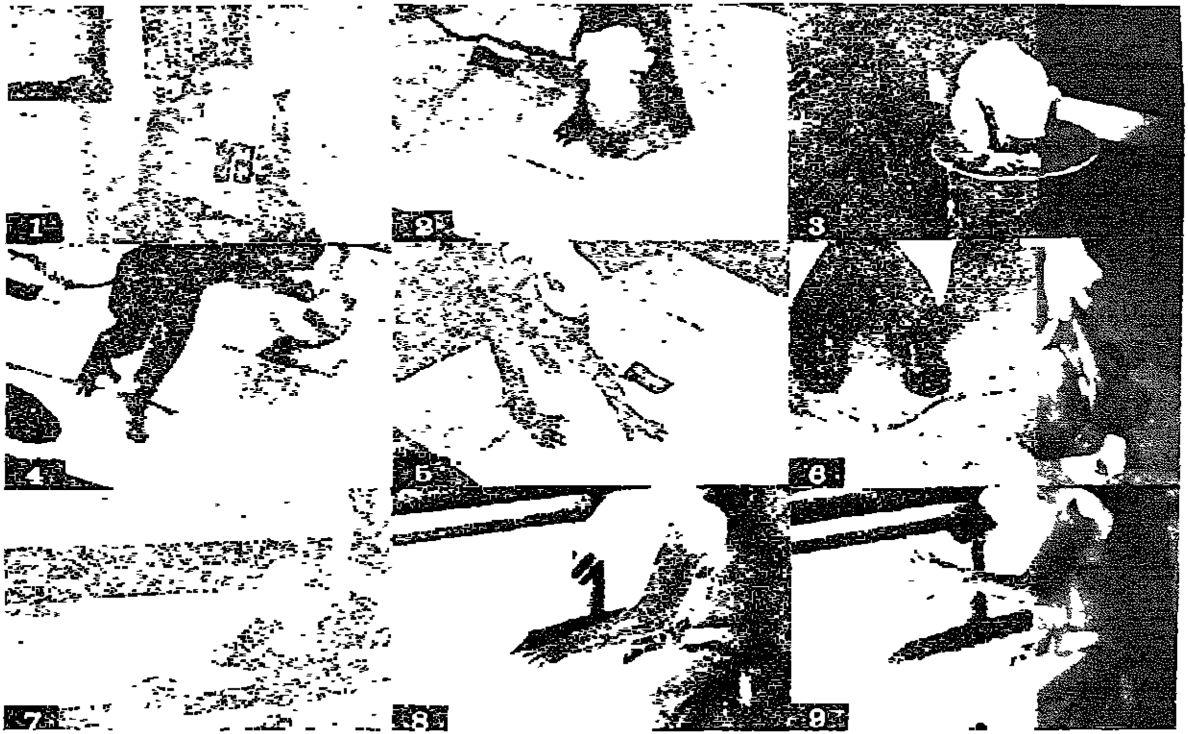
[7] As previously stated, the actual duration of the period of inversion was 168 hours, or seven days The protocols, however, are reported in terms of the eight calendar days over which this period extended.



FIGURES 1-9

Figures 1-2 (2nd calendar day of lenticular inversion) and 3 (8th day)—*tonic immobility*, Figure 4 (3rd day)—resistance to *forward walking*, Figure 5 (3rd day)—*backward walking*, Figure 6 (8th day)—*somersaulting*, Figures 7 (3rd day) and 8-9 (5th day)—*interference effects in localization* of underestimation, overestimation, and lateral reversal, respectively.

of visual inversion was to elicit a marked tonic immobility (cf. 16). The animal became purely passive, assuming a bent-over posture, with head drooped forward and muscles in a state of tonic contraction. During such time, overt response to stimulation was difficult to elicit; in order to evoke such a response it was necessary to increase considerably the intensity of the stimulus. At intervals of approximately 3-4 minutes, she would squirm about, raise her head, and seemingly look around, these squirmings being immediately followed by another inactive period of similar duration. Figures 1, 2, and 3 illustrate this tonic immobility at various stages during the period of lenticular inversion.

During such periods the subject showed a marked thigmotropism—a tendency to push against the substratum with the trunk or extremities and a tendency to grasp something with the hands or feet, such as parts of the restraining chair, lens tubes, hands or arms of the experimenter, or—if nothing was available—grasping one foot with the other.

When in such a state of tonic immobility, the animal would allow food to be placed between her lips, but would make no effort to chew or swallow. Her jaws were firmly closed, and bits of even the preferred foods (raisin, apple, peanuts, banana) would thus remain protruding from her mouth for long periods of time, eventually falling to the floor when the more or less periodic squirming movements occurred. At 4:30 P.M., she was finally induced to eat four small pieces of orange, placed directly in her mouth by the experimenter, although she would not reach for them, nor would she transfer them to her mouth if placed in her hand.

When placed in sitting posture on the floor, she would bend her trunk and head forward, the tips of the lenses almost touching the floor between her legs. When moved about by the experimenter, who held her by the arms behind her back, she would walk forward without resistance, but objected vigorously to walking backwards. The animal doubtless had her eyes closed a large part of the time during this early period, and it was evident that when forced to walk on her hind feet she was relying on previously established sensorimotor coordinations. When placed on a high stool, for example, she stepped off without hesitation, and had to be caught by the experimenter.

When being transferred to the Primate Laboratory, shortly after the lenses had been put in place, the subject made repeated efforts, at intervals, to free herself, always pushing with her hind legs, stiffening and straightening out her body, and attempting to lunge forward and upward. The last-named tendency was so strong that she would press her head and upper back against the top of the transfer cage and keep pushing.

The above findings was confirmed later in the day, when, after 15-20 minutes of forced exercise, she voluntarily raised up on her hind legs and walked forward, but became unbalanced and resumed her characteristic tonic, immobile posture. At times she also showed a tendency to jump up into the air On one occasion, when partially released while on the floor, she started to turn over sideways.

Breathing was usually regular, but shallow. If suddenly spoken to or otherwise auditorily stimulated, she would grimace and utter a sharp guttural bark; otherwise there was no vocalization. There was no nausea whatsoever, in marked contrast to the previous results of Stratton, Ewert, and Peterson on human subjects[8]

b. Second Day: Wednesday, June 24, 1936. Tonic immobility persisted, the animal spending most of her time in the characteristic stooped posture, with trunk leaning forward, hind legs drawn up close to the body, and head bent forward and partially resting on the knees. At 10:00 A.M. she ate bread, conveying it to her mouth if it were placed in her hand It was stored in the cheek pouches.

At 12:30 P.M. a definite incoordination of arm and leg movements was noticed, indicating that the animal was opening her eyes and beginning to respond to the new visual cues with consequent interference effects. Walking behavior was asynergic. After such an incoordinated attempt, she would refuse to walk at all; and would squat on the floor, with toes outstretched and legs far apart.

At times, while sitting on the floor, the subject would cock her head to one side and try to turn over. During periods of forced walking, she would frequently jump up and throw her feet upward and outward, also indicating that the reversal was taking effect.

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[8] The failure of the monkey to show nausea under conditions of prolonged lenticular inversion offers a problem for future work The vestibular mechanism does not seem to differ markedly from that of man, and hence a fruitful hypothesis might attribute the lack of nausea to the more frequent climbing and jumping behavior of the monkey in its everyday life, with periods in which the animal is literally upside down In fact this hypothesis is not irrelevant to the general problem of readaptation to experimentally produced visual inversion

At 8.00 P.M., when bread was held in the visual field approximately 12-16 inches from her eyes, she reached out her hand, and on failing to reach and grasp it, became emotionally upset and struggled to remove the lenses and to get free. When bread was held outside of the visual field, for olfactory control, no positive reaction occurred.

At 8.30 P.M., when raisins were used, she reached on the opposite side to that of presentation. These results were obtained on 12 consecutive trials, both when right and left hands were used (but singly) and for all stimulus positions in the field. She also under-reached the incentive, her hand closing on an nearer than and to the opposite side of the incentive. The subject was rewarded on each trial, the raisin being placed in her mouth if she failed to "compensate" for the original discrepancy and reach the food by a series of trial and error movements. A second series of 12 trials, using banana as the incentive, showed the same reversal of localization. Frequently she compensated after her hand was in the visual field along with the stimulus, i.e., she moved her hand, randomly at first, but later guided by visual cues, until it reached the stimulus. This compensation became more and more frequent. The errors of under-reaching, over-reaching, and lateral reversal are illustrated in Figures 7, 8, and 9.

At 9:00 P.M. she refused to walk forward voluntarily (cf. Figure 4), and when forcibly "swung" or pushed forward (*E* holding her two arms behind her back), she spread out her legs and toes, stiffened her body, and tried to stop. In contrast, she "walked" backwards readily and at times voluntarily (cf., Figure 5). The above behavior was not so pronounced if she was not looking at the floor, i.e., the act of looking down at the floor and at her feet seemed to facilitate backward walking and to inhibit forward locomotion. When placed on a high stool, instead of stepping oft inadvertently, as on the first day, she hesitated on the edge, and then very deliberately put her head down and started to get off head first. She was almost perpendicular when her feet left the stool, and had to be caught by the experimenter.

When held in a rough standing position by the outstretched arms, she often attempted to turn over. She would "push oft" with her hind legs, throw them outward and upward, and throw her head forward and downward. At other times she would leap in the air, as she had done during the first day of visual inversion No nausea was observed

c. Third Day. Thursday, June 25, 1936. The subject continued to show tonic immobility caused by lenticular inversion, as evidenced by stooped tonic posture even when not restrained. Spasmodic or "nervous" jerks frequently appeared—rapid twitchings of the entire body musculature. The thigmotropism was also strong, e.g, she was on one occasion found sitting with one foot grasping the other and with the latter grasping a loose cord from the experimental chair.

During exercise, the same incoördination of bodily movements was noticed. Forward walking continued to be inhibited, whereas backward movement was not (cf, Figures 4 and 5) The tendencies to jump and to turn over were also evidenced Bi-manual coördination, in the sense of simultaneous cooperation of the two hands in manipulating objects, showed a marked interference effect. The subject seemed better able to compensate for spatial discrepancy in reaching, although reversal errors of localization were sometimes large. The pseudoscopic effect of inversion was illustrated when pictures were being taken at 1·00 P.M : when a fly buzzed 3-4 yards from her head, she reached only one foot in front of the lenses to slap at it.

Appetite and elimination were good. There was no nausea.

d. Fourth Day· Friday, June 26, 1936. Tonic immobility persisted. If left alone on the floor, body and head were usually bent forward, with lenses almost touching the floor, and there was a definite tendency to roll over in a forward direction. At times, the subject raised her head and slowly moved it around in all directions.

Spatial localization continued to show a discrepancy between left-right, up-down, and far-near positions (cf, Figures 7, 8, and 9), although there were fewer errors and of less magnitude During the afternoon an increase in general activity was noted, indicating increased use of the new sensori-motor cues. Periods of tonic immobility were repeatedly observed to follow immediately periods of heightened activity and visual (?) strain, the animal raising up on her hind feet, twisting her body, reaching out with her arms and moving her head around as if looking in all directions, and then suddenly resuming her typical crouched, immobile position.[9]

The animal continued to refuse to walk forward, but could be walked backward readily. It should be noted in this connection that if far objects look near when wearing the lenses, the subject would seem to approach objects by walking backward.

When placed on the edge of a table or high stool, she went down head first; but since she was being held by her outstretched arms, she turned a complete forward somersault, her body going between her arms. During the day she turned this somersault at every opportunity (sometimes two in a row), even when she was merely held in an upright (standing) position on the floor. In every case she would begin by putting her face down on the floor, sometimes raising up her hind legs and completing the somersault and at other times stopping there and looking backward between her legs, thereby partially re-inverting her visual field.

Her appetite continued good, although she would take little milk, pushing the mouth bulb away in a sporadic fashion. No nausea.

e. Fifth Day· Saturday, June 27, 1936. There were no particularly new behavioral developments on the fifth day. General activity and frequency of attempts to move about in the room showed an increase. There was still a marked interference effect from the lenticular inversion. Previous observations regarding the onset of tonic immobility following a period of activity were confirmed.

The previously reported posture, localizing behavior, forward and backward walking, jumping, and somersaulting were also exhibited. Eating and elimination normal. No nausea.

f. Sixth Day. Sunday, June 28, 1936. During the day there was an increase in spontaneous activity and sensori-motor coordination. Seeing a cup of peanuts on the table, the monkey climbed up on a chair and onto the table, dropping some on the floor, she climbed down after them She also showed remarkable exploratory behavior, but was still quickly affected by activity and visual strain, assuming the tonic, quiescent, bent-over posture.

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[9] The writer has elsewhere suggested (16) that this behavior may illustrate the visual mechanism involved in such a phenomenon, i.e., tonic immobility resulting, in such a case, from a period of direct perceptual gaze and visual exploration. Such a mechanism would give rise to the frequently observed periods of general activity interspersed with the relatively sudden onset of a short period of tonic immobility.

Reaching and spatial localization of visual stimuli also showed marked improvement during the day. Whereas at 9:00 A.M. reaching movements to visual stimuli seemed largely random and showed frequent reversal effects, by 9:00 P.M. the animal was able to locate spatially presented incentives with only a few exploratory movements. She could reach the table and chair at proper levels with no localization error. Olfactory perception was keen; she would start reaching and groping at the slightest trace of food odor. Tactual discrimination was also good, e.g., banana under foot was felt and located immediately without error. There was also accurate localization (reaching) of any point on her body not in the visual field. In such cases, of course, the subject was making use of old localization habits. If the incentive was presented in the visual field, however, certain trial and error movements were still required, although they were more accurate than formerly.

For the first time, the subject began to walk forward a little, rearing up on her hind legs; several times, however, she almost lost her balance and fell backward. Coming to the edge of a stool or table, at 10:00 P.M., she looked down but did not go off head first. She first retreated—by scooting backwards, but later turned around and climbed down feet first. This was in marked contrast to the behavior on the first few days of inversion, when she fell off head first.

The animal continued to turn somersaults, if held erect or semi-erect by the arms. She ate a wide variety of foods, and showed no signs of nausea.

g. Seventh Day: Monday, June 29. 1936. Spatial orientation showed considerable improvement, sensori-motor coördination was good, and general activity index was high, although occasionally the subject would lapse into tonic immobility for a short time During observation periods, she walked around freely, a large part of the time standing up on her hind legs, with body arched and head back and up. She also recognized her location in the laboratory, once walking through three other rooms direct to the primate quarters. Taken into the housing arena, she climbed around the caging, going up and down the grilling in normal fashion. She recognized and walked through doorways in various parts of the laboratory, climbed up and down from tables, chairs, etc.

She reached for incentives with a small amount of trial and error;

on approximately 20 per cent of the trials the localization was perfect. She seemed to perceive general locations and usually to rely on minor adjustments for specific localization When food was held directly underneath the lenses close to the face, the animal did not reach, indicating that reaching responses were not instigated by olfactory cues She relied much on tactual cues when objects were within reach but outside her restricted range of visual apprehension.

She continued to turn forward somersaults. Appetite was normal. There was no nausea.

h Eighth Day Tuesday, June 30, 1936 (until 2:00 P.M.) Observation during the morning indicated that virtually complete readaptation to the lenticular inversion had occurred, as revealed by overt localizing responses A large part of the animal's time was spent in exploration She walked voluntarily through the laboratory to the primate quarters, climbed around the inside of the housing arena, and unlocked the door of her own cage, which she had not occupied since the beginning of the inversion experiment. She climbed inside, and after a time climbed up on to the wooden shelf in the rear of the cage. Her presence here seemed to revive former sensori-motor habits, for she arched her body, put her head down, and pushed up against the top of the cage.

Walking and climbing appeared normal, without the interference which had characterized the early days of lenticular inversion. The subject continued to turn somersaults, as before (cf., Figure 6). States of tonic immobility occurred after periods of stress and strain, although they were briefer and less intense than those shown during the early period of inversion. No nausea was exhibited.

The lenses were removed at 2:00 P.M

i Post-Inversion Period—First Day: Tuesday, June 30, 1936 (after 2 00 P M) Immediately after the lenses were removed, the subject looked around, blinked her eyes, and ran around the room. There was a slight but definite motor incoördination, especially in climbing and jumping, although this did not persist. When given the opportunity, she ran to the primate quarters, going to her cage and getting inside In moving about, she did not walk erect, as during lenticular inversion, but ran in the normal way on all fours.

Posture was normal. There were no evidences of tonic immobility She no longer turned somersaults; in fact, repeated attempts to force her to do so resulted in only one partial success, the subject having great difficulty in getting over Reaching responses to incentives held in various parts of the visual field showed no pronounced effects or disabilities

The animal was relatively docile. Her appetite was good No traces of nausea could be observed, either immediately following removal of the lenses or throughout the day

At 7:30 P.M , 5½ hours after removal of the lenses, an observation was made which revealed that specific interference effects remained even at this time When the door of her cage was opened, the subject jumped down (forward) from her board perch on to the floor of the cage, but she clearly misjudged the distance in her jump, hitting the floor too soon. She was coaxed back up, and induced with incentives to make repeated jumps over a period of time She definitely showed a lack of spatial estimation, and, after four jumps, resorted either to going to the side of the cage and cautiously jumping down with her hand on the side wall, or turning around and climbing down backwards. There was no deficiency in climbing upward on to the shelf No other evidences of atypical behavior were observed during the remainder of the day.

j Post-Inversion Period—Second Day. Wednesday, July 1, 1936 All behavior appeared normal with the exception of jumping downward, even from a height of only two feet. She always hesitated, showing an almost trial and error reaction pattern She rarely jumped down head and forelegs first, as she always did pre-experimentally, on such occasions overjudging the distance In fact, at times she did not get her forelegs in place in front of her in time. Usually, she climbed down feet first or else put her hand against the side wall while jumping down.

k Post-Inversion Period—Third Day Thursday, July 2, 1936 The animal continued to show some hesitancy in jumping down from a chair, stool, etc , although readaptation was virtually complete.

D SUMMARY

The purpose of the present investigation was to determine experimentally the effect of inverted retinal stimulation upon spatially coordinated behavior when complete retinal inversion is present in all visual stimulation over an extended period of time. It was also desired to test the feasibility of such experimentation on the animal subject

The subject was an adult female rhesus monkey, approximately nine years old. The optical system employed to achieve inversion consisted essentially of binocular astronomical telescopes with detachable lenses mounted in aluminum tubes, the latter threaded securely into the brass bushings of a form-fitting aluminum mask. The mask was held in place by a leather headgear fastened with straps and surgical adhesive, so that no light could reach the eyes except through the lenses The interpupillary distance was correctly observed, and the lenses were chromatically and aplanatically corrected so as to furnish a clear, well-defined and maximal field of view at an established fixation distance of 16 inches. The reversing lenses were worn continuously for a period of exactly seven days. The subject was at first necessarily restrained in a special chair and head holder, being removed for periods of exercise and observation; the restraint was decreased as the subject became adapted to the situation. Observations were made in the form of detailed protocols and by cinematography.

The initial results of inversion indicated a marked tonic immobility. The animal remained purely passive, assuming a bent-over posture, with head drooped forward and muscles in a state of tonic contraction. It was evident that when forcibly moved about, the subject was relying on previously established sensori-motor coördinations There was a marked thigmotropism. No nausea was explicitly observable, in marked contrast to previous results on human subjects.

With continued inversion, there was a progressive decrease in the frequency and duration of the periods of tonic immobility, coincident with an increase in general bodily activity. A pronounced interference effect was noted in the case of all visually stimulated behavior Walking was asynergic. Forward walking was inhibited, whereas backward movement was not. Tendencies to jump up into the air and to turn over were also noted. Reversal effects in reaching for incentives in the visual field were observed, the subject reaching nearer than, and on the opposite side to, that of presentation. Bimanual coördination also showed a marked interference effect.

By the fourth and fifth days, there was a marked increase and improvement in general activity, although tonic immobility still persisted. Spatial localization continued to show a discrepancy between left-right, up-down, and far-near positions, although there were fewer errors and of less magnitude Compensatory movements, after the subject's hand was in the visual field along with the incentive, became more and more frequent and adaptive. Somersaulting also appeared

By the final day of inversion, readaptation, as revealed by overt localizing responses, was virtually complete. A large part of the subject's time was spent in visual exploration Walking and climbing appeared normal, without the interference which had characterized the early days of lenticular inversion. The subject continued to turn somersaults, as before. States of tonic immobility occurred after periods of stress and strain, although they were brief and less intense. No nausea whatsoever was exhibited

Upon removal of the lenses, slight interference effects were noted, but most of these quickly disappeared. There was a slight but definite motor incoordination, especially in climbing and jumping. When jumping from a platform to the floor, the animal showed errors in spatial estimation, hitting the floor too soon This error and the resulting hesitancy in jumping persisted for approximately three days.

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COMPREHENSION DIFFICULTY AND INSPIRATIONAL VALUE*

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There have been several movements toward a simplification of vocabulary in literature. The basic reason in each case has been to obtain better comprehension, although the authors have sometimes had different groups in mind as they have written these simplified versions. (*a*) Bates (1), Goodspeed (3), Moffatt (5), and others have sought to write the Bible in words and form more familiar to the public. (*b*) The exponents of Basic English (6) have worked for easy translation by foreigners and for an international language. (*c*) Thorndike (8) has suggested that a way to improve children's reading ability is to write their literature within their vocabulary grasp. Several classics have been rewritten to fit the vocabulary level of their usual grade placement. (*d*) The even more difficult problem of providing literature for reading disability cases—literature that is at their adolescent interest level but is written within their meagre vocabulary ability—has within recent years motivated the production of literature in very simple vocabulary.

One reaction to these simplifications has been that they destroy some, if not all, of the literary, the admiration, or the inspirational value of these selections. The original author presented the impression he wished to give through a judicious selection of words, readers over a long period of time have acclaimed these descriptions as excellent, as "classics," now, to substitute homely words for the original is like giving a gourmet's son some pap labeled as ambrosia. The rewriters, however, proclaim that "comprehension is necessary for appreciation" and that if children and the common people are to enjoy their literature it must be simplified.

The purpose of this series of experiments is to study the effect of

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simplification of literature on its inspirational value. Inspirational selections rather than narrative prose are used because greater definiteness and clarity of instructions can be obtained in choosing the "more inspirational" over choosing the selection with the most "literary merit." This purpose is carried out through a paired comparison technique in which large numbers of people decide which of two selections they consider the more inspirational. No mention is made to these people that they are comparing an original and a simplified version, they are merely requested to choose the selection that they like the better. In selecting original and simplified versions to compare, care has been taken to use published simplifications written by qualified writers—this insures equivalence of meaning and a smooth style in the two versions.

The following experiments involving *Bible, Peace Pact,* and *Gibbons* are presented in their chronological order of completion.

A. BIBLE

The first experiment concerns a comparison of selections from the King James and the Goodspeed versions of the New Testament. The former can be considered the traditional and more difficult version while the latter represents a typical modern version (actually the author sought the most simplified version and the most simplified selections therein).

Because knowledge of the purpose of the experiment might allow preconceived notions to determine the results rather than personal impressions, an attempt was made to mask the actual purpose of the experiment from the subjects. This was done by comparing two different selections, say *"A"* and *"W,"* with the instruction to choose the more inspirational. For one group *"A"* was in the King James and *"W"* was in the Goodspeed version, for a second and comparable group *"A"* was in the Goodspeed and *"W"* in the King James version. The difference in style was not announced, so the comparison appears to be between the actual selections. The effect of "simplification" is then measured by comparing the per cent of Group I that preferred selection *"A"* (King James) with the per cent of Group II that preferred selection *"A"* (Goodspeed). A series of such comparisons adds to the definiteness of the conclusions.

In order to minimize factors other than difference in style of writing, each pair of selections was matched in terms of length, theme, writer, location in the Bible, and inspirational value. A preliminary series of 25 pairs of selections, judged to be equal in the above respects, was reduced to the seven best pairs in the writer's judgment. These seven pairs, all in the King James version, were presented to 45 subjects with instructions to choose the one selection in each pair which they considered best. The four pairs most equal, e.g., each member of the pair tended to be chosen about equally often, were then used in the actual experiment. The location of these selections in the Bible, the directions used, and two sample selections are given below.

A[1]	*Luke* 18 10-14	W	*Luke* 14 8-11
D	*Mathew* 20 1-16	Z	*Mathew* 25 31-46
B	*James* 1 2-15	V	*James* 2 14-26
E	*Romans* 6 1-11	X	*Romans* 14 1-9

DIRECTIONS

There are no "correct" answers to this test. The purpose of the test is to obtain *your judgment* as to which selection, in each group of two, is the more inspirational. That is, which one of the two selections would make the better basis for a sermon, would teach the better moral, or if followed would lead to a better life.

A

Two men went up into the temple to pray, the one a Pharisee, and the other a publican. The Pharisee stood and prayed thus with himself, God, I thank thee, that I am not as other men are, extortioners, unjust, adulterers, or even as this publican. I fast twice in the week, I give tithes of all I possess. And the publican, standing afar off, would not lift up so much as his eyes unto heaven, but smote upon his breast, saying, God be merciful to me a sinner. I tell you, this man went down to his house justified rather than the other: for every one that exalteth himself shall be abased; and he that humbleth himself shall be exalted.

W

"When someone invites you to a wedding supper, do not take the best place, for someone more distinguished than you

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[1] Hereafter reference to these selections will be by these letter symbols.

> are may have been invited, and your host will come and say to you 'Make room for this man,' and then you will proceed in confusion to take the poorest place. But when you are invited anywhere, go and take the poorest place, so that when your host comes in, he will say to you, 'My friend, come to a better place.' So you will be shown consideration before all the other guests. For everyone who exalts himself will be humbled, but the man who humbles himself will be exalted."

In this experiment Group I compared the King James version of Selections *A, D, B,* and *E* to the Goodspeed versions of *W, Z, V,* and *X,* respectively; Group II compared the Goodspeed versions of Selections *A, D, B,* and *E* to the King James versions of *W, Z, V,* and *X,* respectively. The results of the experiment are summarized in Table 1.

TABLE 1

PERCENTAGE OF SUBJECTS PREFERRING A SELECTION IN THE KING JAMES OR IN THE GOODSPEED VERSION OF THE BIBLE WHEN THE TWO ARE COMPARED

Selection preferred	% Preferring in King James vers (Group I, N=146)	% Preferring in Goodspeed vers (Group II, N=153)	Critical Ratio*
A (in A vs W)	68	69	0.20
D (in D vs. Z)	71	57	2.55
B (in B vs. V)	42	44	0.35
E (in E vs X)	33	44	1.96
Average A, D, B, E	53.5	53.5	0.00
	% Preferring in King James vers. (Group II, N=153)	% Preferring in Goodspeed vers. (Group I, N=146)	
W (in A vs W)	31	32	0.20
Z (in D vs. Z)	43	29	2.55
V (in B vs. V)	56	58	0.35
X (in E vs. X)	56	67	1.96
Average W, Z, V, X	46.5	46.5	0.00

In terms of the standard error of a proportion.

This table should be read as follows: 68 per cent of Group I (N=146) prefer Selection *"A"* (in King James) to Selection *"W"* (in Goodspeed), 69 per cent of Group II (N=153) prefer Selection *"A"* (in Goodspeed) to selection *"W"* (in King James). The difference between Group I's liking for *"A"* in the King James and Group II's liking for *"A"* in the Goodspeed is not great enough to be statistically significant Nor for the other three pairs is there any significant difference It will be noted that the percentages and the significances of the differences for Selections *W*, *Z*, *V*, and *X* are a function of the same results quoted for Selections *A*, *D*, *B*, and *E*. Averaging the per cents in each group that like the paragraphs in the King James version, and averaging the per cents in each group that like the paragraphs in the Goodspeed version gives an equal selection of the two styles.

Possibly people with deeper religious feeling will show more definite reactions on these comparisons Each person checked one of the following on his test

a Church member and in regular attendance.
b. Regular church attendance, but not a church member.
c Church member, but do not attend very often
d Not a church member and very seldom attend

As a further check, each person also indicated his approximate number of attendances at church functions during the past twelve months. The percentages of each of these groupings that preferred the original version were: "*a*" 49.6 per cent; "*b*" 50.0 per cent; "*c*" 50.9 per cent; "*d*" 49.7 per cent. These percentages are so nearly alike that they indicate that church activity probably has little effect on a preference for the King James or the Goodspeed versions.

Difference in type of religious material does not seem to make a great deal of difference on the effect of style of presentation. Pairs *A-W* and *D-Z* were selected from the parables, while Pairs *B-V* and *E-X* were selected from the more mystic and less comprehensible sections of the New Testament. If in Table 1, the average of the per cents preferring the Parables in the original (53.25 per cent) and in the simplified form (46 75 per cent) are compared, and the average of the per cents preferring the more mystic in the original (46 75 per cent) and in the simplified form (53 25 per cent) are compared, no reliable nor consistent trend is found.

These results indicate that when people compare biblical selections, half of which are in the King James version and half in the simplified Goodspeed version, there is no consistent preference for style of presentation. Close attachment to the church or the type of Bible literature does not seem to make any difference in these results.

B. PEACE PACT

The second experiment was carried out for two reasons: (*a*) to see if a direct comparison of an original and a simplified version would show any difference, and (*b*) to see if a greater dissimilarity between the versions would show any difference.

In this experiment, the original preamble to the Kellogg-Briand Peace Pact (9) was compared to one written in Basic English (6, p 251-3). The directions and the two preambles for comparison are given below It will be noted that no mention is made of comparing an original with a simplified version.

> Which one of these two preambles do you consider the more inspirational, and therefore the more fitting, as an introduction to the Kellogg-Briand Peace Pact?
>
> *A*
>
> The President of the German Reich, the President of the United States of America, His Majesty the King of the Belgians, the President of the French Republic, His Majesty the King of Great Britain, Ireland and the British Dominions beyond the Seas, Emperor of India, His Majesty the King of Italy, His Majesty the Emperor of Japan, the President of the Republic of Poland, the President of the Czechoslovak Republic,
>
> Deeply sensible of their solemn duty to promote the welfare of mankind,
>
> Persuaded that the time has come when a frank renunciation of war as an instrument of national policy should be made to the end that the peaceful and friendly relations now existing between their peoples may be perpetuated;
>
> Convinced that all changes in their relations with one another should be sought only by pacific means and by the result of a peaceful and orderly process, and that any signatory Power which shall hereafter seek to promote its national interests by resort to war should be denied the benefits furnished by this Treaty,
>
> Hopeful that, encouraged by their example, all the other nations of the world will join in this humane endeavor and by adhering to the present Treaty as soon as it comes into force bring their peoples within the scope of its beneficent provisions, thus uniting the civilized nations of the world in

a common renunciation of war as an instrument of their national policy,

, have agreed upon the following articles:

B

The President of the German Reich, the President of the United States of America, the King of the Belgians, the President of the French Republic, the King of Great Britain, Ireland and the British Dominions over the Seas, Emperor of India, the King of Italy, the Emperor of Japan, the President of the Republic of Poland, the President of the Czechoslovak Republic,

Deeply conscious that they are responsible for increasing the well-being of all nations,

Certain that the time has come when it is right for the nations publicly to give up war as an instrument for profiting themselves, so that the present peace and the happy relations between them may be kept undamaged,

Being of the opinion that all changes in their relations with one another are to be attempted only in ways which will not be a cause of war, and that such changes are right only as the outcome of a process in which peace and order are respected, and that it is right to keep any Power which puts its name to the agreement and later goes to war for its private interests from profiting by this agreement,

Hoping that, given courage by their example, all the other nations of the earth will join in this wise attempt and by keeping to the present agreement as quickly as it comes into force place themselves within its wise conditions, in this way joining together the educated nations of the earth in a general giving up of war as an instrument for profiting themselves,

have come to an agreement to make these statements in the name of all

Of the 143 subjects making a choice, 51 7 per cent selected the Basic English version while 48 3 per cent selected the original. The critical ratio for the difference is only 0.40 and is therefore not statistically significant.

A direct comparison of an original and a simplified version of a preamble does not produce any consistent trend of inspirational preference by a group of college students and school teachers

C. GIBBON'S ON "ARABIA"

A final experiment was carried out for these reasons: (*a*) While the second comparison was over more dissimilar material than in the first, in this experiment it is proposed to compare a very simple version with an original of rather difficult vocabulary. (*b*) In this experiment, some junior high school students were used to see if their "naiveté" toward literature might exaggerate any differences. And (*c*) factual material was used to see if use of difficult words might be mistaken as an indication of greater knowledge about a subject.

The selection used in this experiment is one taken from Gibbon's *Decline and Fall of the Roman Empire* (2, vol. 5, p. 332-3) and concerns a description of Arabia. This selection and some simplified versions of it were used by Jensen and Schrodt (4) in an experiment on the effect of simplification on comprehension. Since their simplified versions were not the same length as the original, the present writer made up a simplified version from their selections that was of comparable length and informational detail to the original. The original had been rated as of 11th grade difficulty by judges in Jensen and Schrodt's study while the simplified version here is probably at an elementary grade level (see rating of vocabulary difficulty).

The directions and the two selections to choose between are given below.

> *This is an experiment to see if you can tell which author* below knows the most about Arabia. People listen to various musical compositions and can tell which is the better musical composer. Will you read each of the following selections and check the one that you think is written by the author who knows *the most about Arabia?*
>
> *A*
>
> In the half circle formed by the shores of Ethiopia, Egypt, Syria and Persia there extends into the ocean to the south a large piece of land known as Arabia. It looks like a *triangle* with its narrowest part at the north. Thus east and west between the cities of Bassora and Suez or between the Persian Gulf and the Red Sea it is about 750 miles wide. Further south this increases until it is 1,000 miles wide where Arabia borders on the Indian Ocean. *However, the country is longer*

> north and south than it is east and west. From the city of Beles on the Euphrates river in northern Arabia to the narrow strip of water (Straits of Babelmandel) in the south is a distance of 1,500 miles. Most of this land, which is four times as big as Germany, consists of wide deserts of sand and stone in between sharp and bare mountains. Because this country is near the equator, the sun beats down from straight above with a burning heat. These things make a person feel more alone than do the wilds of Tartary in Russia where the many trees and plants give a feeling of comfort and safety.

B

> In the vacant space between Persia, Syria, Egypt and Ethiopia, the Arabian peninsula may be conceived as a triangle of spacious but irregular dimensions. From the northern point of Beles on the Euphrates, a line of 1,500 miles is terminated by the Straits of Babelmandel and the land of frankincense. About half this length may be allowed for the middle breadth, from east to west, from Bassora to Suez, from the Persian Gulf to the Red Sea. The sides of the triangle are gradually enlarged, and the southern basis presents a front of 1,000 miles to the Indian Ocean. The entire surface of the peninsula exceeds in a fourfold proportion that of France; but the greater part has been justly stigmatized with the epithets of the stony and the sandy. Even the wilds of Tartary are decked by the hand of nature with lofty trees and luxuriant herbage, and the lonesome traveller derives a sort of comfort and society from the presence of vegetable life. But in the dreary waste of Arabia, a boundless level of sand is intersected by sharp and naked mountains, and the face of the desert, without shade or shelter, is scorched by the direct and intense rays of a tropical sun.

Two hundred fifty-one students in eight classes, which included a range from junior-high-school, remedial-reading sections to advanced college classes in psychology, responded to this test with the results indicated in Table 2.

It will be noted that the difference in judgment in the whole group is not reliable, but there are some interesting differences within the classes taught by a given teacher. The writer's only, and certainly not complete, explanation of these contrary "statistically significant" differences is that the teachers may have taught their

TABLE 2

PERCENTAGE OF SUBJECTS PREFERRING AN ORIGINAL OR A SIMPLIFIED VERSION ABOUT ARABIA WHEN THE TWO WERE COMPARED DATA PRESENTED BY TEACHER GROUPS AND AS A TOTAL

Teacher	N	% Preferring simplified	% Preferring original	Critical ratio
W—2 classes*	44	75	25	—3.85
V—4 classes*	101	23	77	+6.13
R—2 classes*	96	46	54	+ .80
Total	241	43	57	+2.30

*W's classes were for remedial reading problems in junior high school. V's classes were two seventh grade middle and low sections in English, and two high school classes in advanced English and in psychology. R's classes were in psychology in college

The writer is greatly indebted to Miss Golda Van Buskirk and Mr. James V. Williams for assistance in administering this part of the experiment.

students different biases toward this aspect of literature and that in giving the tests they may have *unconsciously* influenced their classes. The writer is sure, however, that each person consciously endeavored to administer the test in a comparable manner. *"W"* was working at the time on a problem in remedial reading emphasizing the value of simplified materials—both of his sections preferred the simplified versions. *"V"* is a teacher of high school English—all of the sections tested by her preferred the original version.

D. DISCUSSION

This study has concerned a comparison between original and simplified versions of various selections in different classes and situations in order to find which style of writing fulfills the stated purposes (more inspirational or more informational) the better. Material included two types of literature from the Bible, an inspirational preamble, and a factual selection. People taking the tests included teachers, college students, senior high school students, and junior high school pupils. Out of a total "N" of 693, less than 25 per cent represent duplication of subjects. Comparisons were made between people of more intense and less intense attitudes (religious) and comparisons were made between matched selections and between two versions of the same selection. No consistent trend of preference was found. Of all the comparisons made, 21, only two were statistically significant and these were in opposing directions on the same test.

Possible masking phenomena should be evaluated. (*a*) Was the method too crude? Standard psychological procedures were used. The comparisons were more direct than is life, where one rarely has access to the other version when reading; a direct comparison should exaggerate any difference. Sometimes if a statistically reliable difference cannot be shown, a consistent trend in the differences will have value. No such consistent trend was found in the results of these experiments.

(*b*) The selections and their simplified versions might not be different enough to be typical nor to be of importance. The writer started this experiment with the belief that a preference for the original could be shown. He set about selecting original and simplified versions that were as far apart as possible in order to demonstrate this. A comparative rating of differences in difficulty of the originals and their simplified versions is given in Table 3. It shows difficulty

TABLE 3

COMPARATIVE DIFFICULTY OF THE VERSIONS USED

	No. words sampled	% of words with frequency 2500-10,000*	% of words with frequency over 10,000*
Bible			
King James	1470	6.79	1.33
Goodspeed	1541	5.05	.60
Peace Pact			
Original	243	11.50	2.90
Basic English	270	3.76	.42
Arabia			
Original	208	12.00	2.40
Simplified	209	1.00	.00

*Does not count capitalized letters.

expressed in terms of the per cent of words in each selection classified according to Thorndike's frequency word count (7). The word-distributions afforded by the selections used in these experiments are subject to gross sampling errors, but the percentages obtained will allow some comparative judgment as to their difficulty. It will be seen that the order of increasing disparity of the different versions is Bible, Peace Pact, and Arabia.

These differences are sufficient to produce *statistically significant* comprehension differences between the two versions. On the basis of about seven questions on each Bible selection asked after all inspiration judgments were completed, the critical ratio for the difference in comprehension for the original and the simplified versions of selections *A, D, B,* and *E* is 6.23 (ave. comprehension errors original-group I = 10 99, *SD* = 3.46; ave. comprehension errors simplified-group II = 8 10, *SD* = 3.09), and between the original and simplified versions of Selections *W, Z, V* and *X* is 3.80 (ave. comprehension errors original-group II = 6.05, *SD* = 2.36, ave. comprehension errors simplified-group I = 4 76, *SD* = 2.44). The number of cases in each of these groups was 100. If the questions on the least different of the selections (the Bible) can produce a reliable difference in comprehension, then it can be assumed that the other selections should produce comparable or greater increases in comprehension with their simplified versions. For this reason comprehension questions were not asked in the second and third experiments

Whether the differences between these original and simplified versions are typical is difficult to determine. The small samplings of words in our selections and in word-counts of various books makes comparisons subject to great error. Further, different subject matters of comparable comprehension difficulty may have different word samplings, e.g., these selections have many foreign place-names. The writer did attempt to select typical well-written simplifications and probably leaned in the direction of choosing versions of greater than average difference.

(*c*) The selections used might be so long or so short as to affect a person's choosing. The shortest selections for comparison were 110 and 123 words long (first comparison, *A-W,* in Bible) and the longest comparison was made up of alternate reading of about 1500 words of original and simplified versions of the Bible without interruption for questions In neither case was there a statistically significant difference.

E CONCLUSIONS

In general, it can be concluded, at least for the types of people studied, that:

1. A well-written simplification of an original piece of literature does not decrease its rated inspirational value nor usually its value as an indication of an author's knowledge about a topic.
2. Well-written simplifications of original versions of many pieces of literature will increase the comprehension of its readers.
3. There is some indication that *some* teachers may develop in their groups different biases concerning simplifications.

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WORRIES OF SCHOOL CHILDREN*

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Every culture is characterized by the social and personal problems which it creates for people in the period which it dominates. The culture creates its standards of value. It selects certain problems to be of greater importance than others. These elements may be discovered by means of an analysis of the concerns of people. Such an analysis reveals areas which are of great importance and areas which are of little importance. Certain of these areas are basic to human beings and will reveal themselves in all cultures. Others are distinctive and give color to the special culture which is being studied.

Within a given culture there are differences due to age, sex, social, or economic position. Children have interests differing from adults; employees differ from employers, to some degree boys and girls, and men and women have differing interests. For these reasons an analysis of interests, attitudes, and concerns of people in a given culture must consider these groups separately.

The present article deals with the worries of school children of the fifth and sixth grades in New York City. An analysis is made of the worries of these children to determine what specific problems and what problems of general character are particularly important to them. An analysis of the responses of the children shows how our culture has impinged on them, how certain categories of worries have been selected as causing special anxiety to these children whereas others have been relegated to positions of little importance. Certain sex comparisons are also significant of our culture.

The method used in this study is that of the inventory. This method provides a survey of the attitudes of a population. By means of averages and percentages, certain generalizations can be drawn about children of our day which are normally hidden by the great maze of individual differences.

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[1] Assistance in the preparation of these materials was furnished by the personnel of Works Progress Administration Official Project #665-97-3-6.

1	Failing a test	29	59	12	37	54	9
2.	Witches	5	14	81	6	16	78
3	Choking	14	32	54	13	30	57
4.	Being late for school	17	48	35	25	50	25
5	Having bad dreams	18	43	39	19	48	33
6.	Not having a pretty home	14	28	58	10	21	69
7.	Parents punishing you	19	49	32	15	39	46
8.	Strange people following you	15	32	53	21	42	37
9	Making your parents sad	20	29	51	18	30	52
10.	Not finding a job after leaving school	18	40	42	22	26	52
11.	Getting sick	22	50	28	27	48	25
12	Having a poor report card	27	47	26	22	45	33
13.	Not having nice clothes	13	33	54	15	26	59
14.	Being scolded	17	56	27	16	55	29
15	Mother getting sick	34	45	21	41	40	19
16.	Losing your friends	21	43	36	14	40	46
17.	Not having enough money	21	48	31	16	41	43
18.	Telling lies	16	50	34	16	34	50
19.	Not being treated fairly	18	38	44	12	32	56
20	Losing your fountain pen	20	43	37	17	37	46
21.	Being made fun of by other people	19	38	43	12	33	55
22.	Mother working too hard	43	42	15	47	35	18
23.	Something sad happening to you	20	48	32	22	42	36
24.	Talking too much	18	37	45	11	33	56
25	Mother going away	19	42	39	19	33	48
26.	Spoiling your good clothes	20	53	27	20	44	36
27.	The house burning down	18	29	53	26	19	55
28	Being left back in school	23	33	44	20	29	51

The inventory used in this study was originally constructed as a test to measure *the extent to which children worry.* The test was prepared and standardized by workers on a project of the Works Progress Administration at Teachers College, directed by the senior author It was prepared for use in comparing the emotional attitudes of physically handicapped children to those of normal children.

There are 53 items in the inventory dealing with various problems which are likely to concern children in our culture Each item calls for a choice of one of the responses *"often," "sometimes," "never."* The response chosen indicates the extent to which the child worries about a given item.

The test was given to several hundred children in city schools in the fifth and sixth grades. Table *A* indicates the percentage of chil-

TABLE A

RESPONSES OF CHILDREN TO ITEMS IN WORRIES INVENTORY IN PER CENTS

	Boys			*Girls*		
Items	O	S	N	O	S	N

TABLE A (*continued*)

	Items	*Boys*			*Girls*		
		O	S	N	O	S	N
29.	Not sleeping at night	15	43	42	18	38	44
30.	Not being able to finish school	15	34	51	19	25	56
31.	Doing wrong	19	52	29	19	50	31
32.	Growing up	27	36	37	20	31	49
33.	Kidnappers	13	25	62	27	28	45
34	Being blamed for something you did not do	23	55	22	25	45	30
35.	Father losing his job	27	36	37	28	35	37
36	People telling lies about you	22	51	27	25	43	32
37.	The world coming to an end	17	21	62	18	25	57
38.	Father working too hard	33	43	24	35	39	26
39	Being late for supper	18	52	30	15	38	47
40.	Bad manners	14	40	46	12	34	54
41	Losing money given to you for an errand	20	42	38	14	39	47
42.	Spooky stories	15	29	56	21	31	48
43	Fighting with brothers and sisters	19	43	38	20	45	35
44	Father getting sick	23	45	32	31	38	31
45.	Robbers	16	31	53	22	33	45
46	Getting bad marks in conduct	21	36	43	19	31	50
47.	Death in the family	20	32	48	24	28	48
48.	Saying the wrong thing	14	56	30	14	48	38
49.	Not having the things you need	17	48	35	11	37	52
50.	Hurting people by what you say without meaning to	15	49	36	17	39	44
51	Father going away	24	30	46	23	28	49
52	Getting married	13	27	60	10	20	70
53	Being taken away by strangers	13	26	61	22	22	56

dren answering *sometimes, often, never* for each item. The percentages are given for boys and girls separately. All the percentages in this table are based on 270 boys and an equal number of girls.

In order to establish comparisons between the items it is desirable to assign a single value to each item. After some experimentation it seemed best to use the percentage answering *never* as the value In this way items having a low percentage answering *never* are those of much concern to children. Using these percentages the items may be arranged in order from those indicating much worry to others which cause little worry

The items arranged in order from much worry to little, as indicated by the fact that the per cents in the *never* column range from low to high, are given in Table 1 for boys and girls separately.

TABLE 1

ITEMS ARRANGED IN ORDER OF INCREASING WORRY BY PER CENT ANSWERING "OFTEN" AND "SOMETIMES"*

Rank	Item	Rank	Item	Rank	Item
		Boys			
1	1	21.5	16	40.5	30
2	22	21.5	50	43	8
3	15	24	20	43	27
4	34	24	32	43	45
5	38	24	35	45.5	3
6	12	26.5	41	45.5	13
8	14	26.5	43	47	42
8	26	28.5	5	48	6
8	36	28.5	25	49	52
10	11	30.5	10	50	53
11	31	30.5	29	51.5	33
12.5	39	32.5	21	51.5	37
12.5	48	32.5	46	53	2
14	17	34.5	19		
16	7	34.5	28		
16	23	36	24		
16	44	37.5	40		
16	18	37.5	51		
19.5	4	39	47		
19.5	49	40.5	9		
		Girls			
1	1	19	48	37	28
2	22	20	17	39	9
3	15	21.5	29	39	10
4.5	4	21.5	50	39	19
4.5	11	23.5	33	41	40
6	38	23.5	45	42.5	41
7	14	26	7	42.5	28
8	34	26	16	45.5	19
9.5	31	26	20	45.5	24
9.5	44	28.5	41	45.5	30
11	36	28.5	39	45.5	53
12.5	5	31	25	48.5	3
12.5	12	31	42	48.5	37
14	43	31	47	50	13
15.5	23	33.5	32	51	6
15.5	26	33.5	51	52	52
17.5	8	35.5	18	53	2
17.5	35	35.5	46		

*When several items have the same per cents they are given equal rank.

Items 1 and 2 rank first and last in both lists. The item children worry about most is *failing a test*. The item they worry least about is *witches* It is striking that the improvement in the general level of education relegates the supernatural to last place. Perhaps one should rather say that this is typical of our scientific education. Certainly there have been cultures in the past in which the concern with witches has been much greater This dominance of the realistic over the supernatural will be seen to color all the results In fact one is surprised to note that as many as 19 per cent of the boys and 22 per cent of the girls worry often or sometimes about witches It indicates that superstition is still with us although to a small degree

One may consider the worry of children over failing a test excessive. It may be that a more satisfactory outlook toward school could be achieved if children were not so much concerned with tests as with more constructive elements of the educational program

This consideration of Items 1 and 2 suggests that the remaining items be investigated in terms of their relative rank For this purpose it is desirable to set up a scheme of classification for the items Such a scheme is given in Table 2.

TABLE 2
CLASSIFICATION OF ITEMS IN QUESTIONNAIRE

Category	Items
School	1, 4, 12, 28
Family	15, 22, 38, 44
Personal health and well being	5, 11, 29
Social adequacy	7, 9, 14, 16, 18, 19, 21, 24, 31, 34, 36, 39, 40, 43, 46, 48, 50
Imaginary or unreasonable	2, 3, 8, 23, 25, 27, 30, 33, 37, 42, 45, 47, 51, 52, 53
Personal adequacy	20, 26, 32, 41
Economic	10, 17, 35, 49
Ornamental	6, 13

The classification of the items just set up may of course be questioned. The group included under *"social adequacy"* contains items indicating various types of social awkwardness The items indicate both feelings of guilt towards society and feelings of being mistreated by society. The items in the category of *"imaginary or unreasonable"* include worries dealing with superstitions and other worries which are fanciful like the fear of robbers In this class are also included worries which are clearly remote such as that dealing with marriage, Item 52. Item 41 which concerns losing money is listed in the category of personal adequacy although it has certain economic implications. Two items, 6 and 13, did not seem to fit very well into any of the other categories. We have, therefore, put them into a separate category called *"ornamental."*

Using this classification the highest ranking items may be compared with the lowest. For the boys the first 13 items, those indicating the greatest worry, appear in the following classifications. School, 2 items; family, 3; personal adequacy, 1; health, 1; and social adequacy, 6. In contrast the 13 items showing least worry appear under the following classifications: Imaginary or unreasonable, 11; ornamental, 2. For the girls the 13 items causing greatest concern include: School, 3; family, 4; health, 2, social adequacy, 4. The lowest ranking group of 13 includes: Social adequacy, 4; imaginary or unreasonable, 7, ornamental, 2.

For both sexes the immediate problems of school, family, health, and relations to society are most important. On the other hand problems which are largely imaginary do not concern the children greatly. It is interesting to note that for both boys and girls the problems of having a pretty home or nice clothes are not imporant. These items appear among the lowest 13 for both sexes.

The analysis of the highest and lowest ranking items shows certain sex differences. This is particularly true of the categories of items which deal with personal and social adequacy. Of the first 13 items for the boys seven are of these categories whereas only four appear among the first 13 for the girls. None of these categories appears among the last 13 items for the boys, but four of the lowest ranking items for the girls fall in the category of social adequacy. Evidently the girls feel greater ease in their social relationships than the boys. This situation can probably be explained by the fact that girls mature sooner than boys and therefore make earlier social adaptations.

The comparison of categories of worries may also be achieved by obtaining the average percentage response of the items in each group. These are set up in Table 3. The percents are made up of those who answer either *sometimes* or *often*.

The highest ranking category of worry items is that related to the family. The average worry value of this category of items is about 75 per cent. This shows that children have a *considerable sense of* responsibility toward others. The high ranking of this category

TABLE 3

AVERAGE PER CENT OF THOSE ANSWERING *Sometimes* OR *Often* BY CATEGORIES

Category	Boys	Girls
Family	73	76
School		70
Personal adequacy	65	55
Social adequacy	64	56
Economic	64	54
Health	64	66
Imaginary	46	48
Ornamental	44	36

is also indicative of the important rôle that the family plays in our culture This institution has survived many changes in culture and continues as a dominant institution in our own day.

Sharing honors with the family as a source of concern for children is the school. The high ranking of items in this category shows that children are not at all indifferent to their school progress. The importance of these items to a random sample of city children shows how deeply education has rooted itself into our world outlook. Certainly this type of problem would not have had its present importance in days before universal education.

Of lower rank are concerns dealing with health, personal adequacy, and social adequacy. Allied to these and of about the same rank are economic worries. All of these categories deal with the sense of personal security. It is noteworthy that personal security here takes a place lower than responsibility to family. This human quality of putting interest of others before one's own has important implications for the construction of a well functioning society.

The percentages for the categories of health, adequacy, and economic security are sufficiently great to be noteworthy These per cents show that children are worried by the problems of security in their society. They ask themselves, *"Am I good enough to function adequately in the world in which I live?"* They ask this question widely and frequently.

Items which are imaginary or unreasonable do not play as important a rôle in the concerns of children as do the other categories Children are not entirely free of them as is shown by the fact that 46 per cent of the boys and 48 per cent of the girls are worried about them. Perhaps an improvement in the educational process would cut the percentage even further. In some cases these worries are probably indicative of neurotic tendencies and require an individual psychological approach for their elimination.

The practical approach to life of these children is emphasized by the fact that items such as having a pretty home and pretty clothes are relegated to lowest place both by boys and girls. The order in which the categories appear indicates a sound and responsible attitude by the children. They show themselves to be realistic in their values. They are reasonable and much less beset by superstition than children are usually credited with being.

Certain sex differences appear in this connection. Boys are more concerned with problems of social and personal adequacy than girls. Apparently they feel more awkward than the girls. Economic problems are also of more concern to boys than to girls. Even in this age when men and women both earn money the man has the greater economic responsibility as head of the family. This is evidently brought home early to the children so that boys express greater concern with economic problems.

Differences between socio-economic groups were investigated for nine items which have socio-economic implications. The items chosen for this study were 10, 17, 22, 30, 35, 38, 40, 44, 49. Differing socio-economic groups were selected by means of scores on the socio-economic scale which is attached to the *Pupil Portraits Test*. Scores on this scale were available for 400 children who took the *Worries Test*. The lowest and highest third according to socio-economic score were selected. These thirds then constituted differing socio-economic groups whose responses were compared.

TABLE 4

PERCENTAGE ANSWERING "OFTEN" OR "SOMETIMES" BY SOCIO-ECONOMIC GROUPS FOR A SELECTED GROUP OF ITEMS

Item number	Upper third per cent	Lower third per cent	Difference per cent
10	43	57	14
17	58	67	9
22	88	90	2
30	43	50	7
35	57	67	10
38	76	70	4
40	49	50	1
44	70	73	3
49	50	60	10

For each group the percentage answering either *"sometimes"* or *"often"* to each of the nine items was computed. The results are given in Table 4

The largest differences are found in Items 17, 10, 35, 49, and all four are listed as being in the "economic" category in Table 2 Apparently economic worries are a greater problem to children in the lower economic group than they are to children in the upper The items related to family and the one dealing with manners show very slight differences. Only one item, No. 10—*"not finding a job after leaving school"* shows a difference which is more than twice its standard error and may be regarded as significant For this reason the differences between socio-economic groups cannot be regarded as well established.

A more extensive study of worries as related to socio-economic status is now in progress by comparing responses of children in neighborhoods which differ according to average rent of homes, extent of delinquency, health, and similar factors.

Summary

This article reports the results of a *"worries"* inventory given to 540 children in grades five and six in New York City The group was made up of an equal number of boys and girls. The items have been ranked for amount of worry shown by both sexes When the items are grouped into eight categories, we find that both sexes worry most about family and school items. Next as sources of worry come personal adequacy, social adequacy, economic problems, and health problems. Last of all, imaginary and ornamental. Little difference was found in the amount of worry connected with nine items of socio-economic importance between two groups of children varying in socio-economic status. Only one of these items (*"not finding a job after leaving school"*) showed a statistically significant difference between the two groups of children

The excessive worry of these children about school items would seem to indicate that our school system lays too much emphasis upon *"failing a test," "having a poor report card," "being late to school,"* and *"being left back in school."* We cannot easily reduce children's worries about family matters, but we might very well do so in regard to school matters that are not very significant for the child's future growth and development.

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THE EFFECT OF CRADLING PRACTICES UPON THE ONSET OF WALKING IN HOPI CHILDREN*

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The custom of placing the infant in a device which restrains his movements occurs in many parts of the world. A study of the effects of such restriction of movement should have considerable importance for an understanding of the factors which control the motor development of the young child.

The present paper reports such a study among the Hopi Indians of Arizona. Fortunately among the Hopi it is possible to find the conditions which are necessary to an investigation of the effects of restraint; namely, a group of people which makes use of cradles; and a second group, similar in race and culture to the first group, but which does not place its infants under the same restriction

A CRADLING CUSTOMS OF THE HOPI

Of the present-day Hopi villages, all make use of cradle boards, except the towns of New Oraibi and of Upper Moencopi. The latter two villages have become Americanized to the extent of giving up the use of the cradle. They have also adopted American dress, have given up some of their ceremonies, and in general are less conservative than are the other Hopi towns. Nevertheless, their diet, their nursing customs, and their child rearing practices apart from the use of the cradle board remain virtually unchanged. New Oraibi and Upper Moencopi, therefore, furnish a nearly ideal comparison group for the purpose of contrasting Hopi infants who have not been placed on the cradle with those who have been subjected to this custom.

Hopi culture has been studied extensively. Adequate bibliographies to the anthropological material may be found in the work of Beals (2) and of Murdock (9). However, the Hopi cradling practices have not been described in detail by previous writers and

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†We wish to acknowledge the aid of the Social Science Research Council, which made it possible for us to conduct this investigation

the following account is taken in the main from the authors' own researches.**

In former times the Hopi of all villages used a woven cradle made from the small branches of the sumac *Schmaltzia Trilobata,* but at the present time this cradle is seldom used except on First Mesa, from which only a few of our data are derived. Elsewhere the woven cradle, which required considerable labor and skill for its construction, has been replaced by a heavy board about one foot wide and about two and one-half feet long. At one end of the board is fastened a face- or head-guard of stiff heavy wire This simple device constitutes the cradle on which the infant is firmly secured

In order to place the infant on the board, the child, naked or wearing a shirt or diaper, is put on a cotton blanket which lies on the board The infant's arms are extended by his sides and the right side of the blanket is pulled tight over the right arm and is put between the left arm and the left side and tucked under the infant's body. The left side of the blanket is then pulled firmly over the left arm and tucked under the right side of the child. The part of the blanket which extends beyond the feet is folded back under the infant's legs and buttocks. The infant, thus wrapped, is tied to the board by strips of cloth which encircle the baby and the board. The wrapping includes the legs which are thus fastened so that they can be flexed only to a slight degree. The infant is so firmly wrapped and tied that he cannot turn his body and cannot release his hands from the bindings Only the head which rests on a small pillow or pad of folded cloth is relatively free to move. A piece of thin cloth is placed over the face guard in order to darken the face of the child and to exclude the flies. The cradle, with the infant upon it, lies upon the floor or upon a bed. It is never placed vertically, and is seldom carried about

The infant is thus bound to the board on the first day of life and for the first three months he spends nearly all of his hours in this position Although he is taken off one or more times daily, either for bathing or for replacing soiled cloths, these operations do not consume many minutes and he is returned to the board when they are completed. The infant nurses while tied to the

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**See especially *The Hopi Child* New York, D. Appleton Century, 1930. Pp 225.

board, the cradle with the child attached being held to the mother's breast He sleeps on the board at night as well as by day.

It will be seen that the cradle deprives the infant of nearly all freedom of movement during the early months. These months, of course, are largely devoted to sleep, but nevertheless the importance of "random movements" which occur during this period has been stressed by many writers.

After the early months the cradle board continues to be used in the same general manner as formerly, but the number of hours per day spent upon the board gradually decreases In the later months the degree of freedom of the infant varies from mother to mother and from child to child. The infant may be permitted daily to spend some time unhampered upon the floor. More commonly he is held in arms or on the lap for a while each day. The amount of time spent oft of the cradle gradually increases However, night sleep and daytime naps continue to be taken while he is tied to the board, and on awaking the infant is left upon the board until he becomes restive.

The time at which the cradle is discarded varies greatly Nearly all of those mothers who use it employ it for at least six months Some mothers use it for more than a year. In the case of 14 of our subjects, we inquired concerning the duration of cradle board usage With these cases the average duration of cradling was 9 months, with a range of from 4 to 14 months.

In the two progressive villages the majority of mothers use no restraining devices at all. The infant is dressed in shirt and diaper and covered loosely by a blanket, with his hands free. He is placed in a basket or bassinet or child's bed with no more restraint than accompanies such a position among white American children.

The present report deals only with the age at which the infants of the two groups begin to walk, although data concerning the onset of other motor performances would be desirable Information concerning the onset of walking was obtained from mothers' reports. Whether or not the cradle board had been used was also determined in each case The data were gathered in the summers of 1937 and 1938 The fact that we lived for two summers among Hopi gives us much more confidence in the data than we would have it we had obtained our material from mothers whom we did not know personally.

B. METHOD OF GATHERING DATA

In the gathering of the data for any pueblo we were accompanied by a young woman who was a native of the village. As a rule the interviews were conducted in English, but in some cases the Hopi language was used and our guide served as an interpreter.

Where it was possible, we saw all of the children of a village who were between two and six years of age. Children who were under two years of age are not included in the tabulations, as many children less than two years of age cannot walk and, hence, records of walking for this group would be necessarily incomplete. Only a few children over six years of age were included because we felt that the mother's memory would be less reliable if it covered a period of that length. In all, we secured data on 63 children who had used the board and on 42 children who had not used it.

C. RELIABILITY OF DATA

Among the Hopi, the Gregorian calendar is almost universally used, the birthdays of the children are known, and an accurate knowledge of walking ages seems to prevail. When asked at what age a given child began to walk, the pueblo mother, after a few moments, gave a reply such as, "*A year and one month and a few days*," or "*Two days before the first birthday*," or something equally circumstantial. While we have no check on this point, we are of the opinion that the mothers who were interviewed gave information as accurate as that obtained from white mothers.[1]

One indication of the relative accuracy of the data lies in the fact that there is no unusual grouping of cases in any one month, as shown in Table 1 The cases at one year and at 18 months exceed those of the adjacent months, but scarcely more so than do the reports of white mothers (12).

In questioning the mothers, we asked how old the child was when he first began to walk by himself. If further definition was necessary, we asked when the first steps alone were taken. By

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[1] This is not true of the Navaho At the present time only a few Navaho understand and make use of our calendar. We gathered the walking ages of 55 Navaho children. Of these, 43 of the reports were in terms of "*one year*," "*a year and a half*," or "*two years*." In other words, only 12 in 55 were reported in terms of months We have not thought it advisable to present these data. However, they agree roughly with the material here presented.

TABLE 1
AGE AT ONSET OF WALKING

Age in months	Hopi using board	Hopi not using board	Tewa
24-24.9	2	2	1
23-23.9	1	0	0
22-22.9	0	0	1
21-21.9	0	0	0
20-20.9	1	0	0
19-19.9	4	0	2
18-18.9	7	6	5
17-17.9	0	0	1
16-16.9	3	4	1
15-15.9	3	6	1
14-14.9	15	6	10
13-13.9	6	8	3
12-12.9	10	6	14
11-11.9	9	2	5
10-10.9	2	1	0
9- 9.9	0	1	2
Total cases	63	42	46
Average	14.98	15.05	14.45
Average excluding cases beyond 21.0 months	14.53	14.57	14.05
Standard deviation	2.62	2.24	2.60

examining a number of pueblo infants who were just "beginning to walk" we were able to determine that the phrase "beginning to walk" or its Indian equivalent means taking one or more steps alone which is the criterion that has been used by most investigators. This performance is a point of interest to Hopi parents and is noticed and remembered by them. There was no indication that the phrase differed in meaning for the two classes of mothers.

Our subjects were approximately evenly divided as to sex

D. PRESENTATION OF DATA

Smith *et al.* (12) have held that children who begin to walk at an age greater than 21.0 months seem to make a separate group statistically and that all or nearly all such cases may be instances of retardation due to malnutrition or disease. We have computed averages for our data by two methods, one excluding and one including the most retarded cases among our subjects. The difference between these averages is approximately .5 of a month. Since we wished to compare our material with that of Smith *et al*, our sigmas were computed with the retarded cases excluded, as was done by the authors just mentioned.

Table 1 presents the distribution of the ages of walking recorded by us, together with the averages and standard deviations.

It will be seen that the infants who used the cradle board and those who did not use it differ in average age of onset of walking by only seven-hundredths of a month if we include all cases (the averages being respectively 14 98 months and 15.05 months), and by only four-hundredths of a month if we exclude the cases beyond 21.0 months. This means a difference between the averages of from one to two days. The average age at walking of those who used the cradle board, in both comparisons, is slightly less than those who did not Since the differences are quite insignificant, there is no evidence of an effect of the cradle board upon walking Also, included in Table 1 are the walking ages of 46 children from the Tewa villages of Santa Clara, San Ildefonso, and San Juan These data were gathered in the same manner as the data concerning the Hopi It will be seen that the average age of walking among the Tewa children is not significantly different from that of the Hopi groups

We have shown in a previous communication that the Tewa use a cradle only for daytime naps, a practice which is intermediate to the customs of our two Hopi groups. The lack of a significant difference between the Tewa children and either of the Hopi groups confirms the previous finding that cradling customs do not influence the age of walking. At the same time, the close agreement between the data of the Hopi and the Tewa groups—who differ considerably in language and culture—tends to show the reliability of our method.

We feel that the results of this study are in accord with recent experimental studies on the relation of training to maturation. In general the experimental studies show that additional training or practice above a certain minimum has very little effect upon infant behavior The Hopi infants, while restrained during many hours of the day, are not totally restrained and apparently the activity which is permitted is sufficient to provide the necessary opportunities for motor learning. We see no contradiction in the fact that the Hopi infants are not affected by the cradling practices, while two infants which the present writers subjected to restriction of practice (4) did show retardation in a few responses. In regard to a few responses our experimental subjects were entirely withheld from practice, whereas the Hopi infant who is kept on a cradle board is nevertheless free to act as he pleases several hours per day during the second half of the first year. It will be recalled that our experimental subjects, when given an opportunity, established the missing items in their repertoire with much less than the usual amount of practice.

It is our view that unhampered and healthy infants exhibit motility far in excess of the activity which at any stage of maturation leads to the establishment of the responses characteristic of that stage. Just as it has been found that nature is prodigal in that she has supplied the individual with more kidney tissue and more lung tissue than is ordinarily needed for normal functioning, so apparently has she been prodigal in eliciting in the infant more activity than is needed in the formation of new responses. That is why additional practice has little or no effect upon the infant, and it is likewise the reason why a considerable degree of restraint has no influence upon the behavioral repertoire. We do believe, however, that if activity were reduced below a certain minimum, behavioral development would then be affected.

No data have been published on the motor development of other Indian children, except for some casual observations by Hrdlicka (8). However, there is available a considerable body of material on the walking ages of children of other races and cultures, and it may be of interest to compare the averages of other groups with the averages of our Indian subjects.

Table 2 presents the Indian averages in comparison with the results of other studies which have used the method of mothers' reports. Since Smith *et al* subjected several sets of data to a treatment uniform with ours, our citations in several instances are to the data as presented by Smith and her co-authors rather than to the original data.

It will be seen that the Hopi average is one month greater than the slowest of the comparison groups. This difference is statistically reliable and the other differences of course yield very high reliabilities. In comparison with the most advanced groups of white subjects, the Hopi children are practically two months retarded. While the differences in central tendency are marked, it should be noted that

TABLE 2

AVERAGE AGE OF WALKING AMONG VARIOUS GROUPS*

Race	Location	Average	Sigma	No. of S's	Investigator
White	Seattle	12.77	2.23	831	S Smith (13)
White	California	12.94	2.22	556	Terman, *et al.* (12)
White	United States	12.97	2.35	217	Hrdlicka (3)
White	California	13.20	1.95	61	Bayley (1)
White	Various	13.21	1.68	25	Biographies (6)
Various	Hawaii	13.25	2.27	721	Smith, *et al* (12)
White	California	13.29	2.20	252	Pyles, *et al* (10)
White	Iowa	13.47	1.96	108	Smith, *et al.* (12)
White	New York	13.55	1.55	49	Mead (12)
Hopi Indians	Arizona	14.55	2.51	100	
Tewa Indians	New Mexico	14.05	2.60	44	

*It may be objected that, if our table included Shirley's data, then the Indian average would not seem unusual, for the average age of walking of Shirley's subjects was 14.8 months. Her data are not listed with the others because they were gathered by a different method. In the course of periodic visits to the home, Shirley recorded whether or not she saw the child walk alone. A child might have taken a few steps sometime earlier, but unless this recurred during the examiner's visit he was not said to be walking. This definition of walking is different from the criterion here employed, and averages based on Shirley's method are necessarily greater than averages derived from mothers' reports of the first steps. The inclusion of both types of data in one table would lead to confusion and misunderstanding

the ranges of all groups are nearly identical, and the variability relative to the mean is quite large in all studies.

At the present time we have no information which leads to an understanding of the retardation of the Indian children. Several possible explanations suggest themselves. In the first place, the difference may be due to a constant overestimation of walking ages by the Indian mothers, or of underestimation by the women of the other groups. In our opinion, the differences are too great to be explained in this manner, although it must be admitted that the error of estimation of the Indian women is not known. Pyles *et al.* found that white American mothers, reporting on age of walking when the children were 21 months of age, underestimated the age of walking as determined by direct observation by only four-tenths of a month, whereas the difference between groups is sometimes as great as two months.

The likelihood that the groups made use of different criteria of "walking" is naturally suggested. We have already described the measures which we employed to obtain a criterion which, we feel, is comparable with that used in other studies. It is our opinion that Table 2 refers to real differences and not to differences in estimates and in criteria

Had we not found the cradle board to be without effect, it would have been natural to turn to it as a plausible explanation of the differences. But the present evidence shows that we must turn to other causes.

One of these may be the altitude at which these Indians live, which is between 6,000 and 7,000 feet above sea level. Another environmental possibility of explanation would be a dietary one, as the diet of the pueblo child differs markedly from that of the American child But such speculation is fruitless without further research.

However, our present data force us to point out the dubious correctness of the suggestion made by Smith and her associates (12) that age of walking is greatly influenced by the amount of sunshine and by the average annual temperature. These investigators point out that walking is earlier in Hawaii than in California, and earlier in California than in Iowa and New York, and they note that these regions differ in the same manner in respect to mean annual temperature and hours of sunshine. Yet the pueblo children are the latest walkers thus far reported, in spite of the cloudlessness and the comparative warmth of the Southwest, a fact which would seem to negate whatever evidence other data may have contributed to the theory of climatic influences on the onset of walking.

E SUMMARY

Hopi children who are subjected to considerable restraint of movement by being bound to a cradle board for most of the day during a large part of the first year of life are no slower in beginning to walk than are the children of more acculturated Hopi mothers who have given up the use of the cradle board. The infants who are placed on the cradle board do nevertheless have some opportunities to practice coordinations which may lead to walking. Restraint of the infant is most marked in the early months, and freedom of movement is greatest in the months just preceding the onset of walking.

The lack of influence of cradling upon the onset of walking is interpreted as showing that the activity of the unhampered child is greatly in excess of the activity required to develop the characteristic infantile responses. Movement can be markedly restrained without influence upon walking, and probably without influence upon other responses. It is not held, however, that all movement or all practice could be dispensed with without effect upon behavioral development.

Hopi infants, those who are unhampered as well as those who are restrained, begin to walk at an average age which is four to eight weeks beyond the average age for this performance in any groups previously reported. The cause of this retardation of the Hopi children was not ascertained in the present study.

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WAKING SUGGESTIBILITY IN CHILDREN: GENERAL OR SPECIFIC?*

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A. PROBLEM

In an earlier paper Aveling and Hargreaves (1) reported on the results of administering a number of tests of "suggestibility" to a population of elementary school children of average age 12. In their paper they state. "Such evidence as is forthcoming seems to point to a factor of general suggestibility, rather than to specific suggestibilities, as previously believed" (p. 53), and again, "There is evidence which points to a general group factor of suggestibility" (p. 75)

To test this hypothesis in terms of two of the tests used was one purpose of the experiment here described. A further purpose originated in their treatment of reliability of the measurements, which seems open to rather serious criticism. The two tests in question were for the acceptance on the part of the subjects of suggestions of hand rigidity and hand levitation. The instructions to the subjects quoted in the next section of the present paper will make clear the nature of the tests.

The concept of reliability is used by Aveling and Hargreaves in rather widely varying senses as witness the following quotations

> As it [the test of hand rigidity] was performed only once with each subject, there was no possibility of obtaining a reliability coefficient (pp 55-56)
>
> The reliability of the two divisions was for the boys, $r = 64$, for the girls, $r = 99$ (p 58).
>
> The test was given twice, once for each hand, and the

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[1] Responsibility for this study is divided as follows. Remmers planned the experiment, made the necessary arrangements, planned the statistical analysis, and prepared the paper here presented. Cutler and Jones did the laboratory work, made the tabulations, and did a part of the computational work

> reliability right hand *vs* left hand worked out $r = .99$ (p 63).
>
> The test was performed twice with each subject, once sitting and once standing The reliability between the two was Boys, $r = .81$; girls, $r = .93$ (p 64)

Each and all of these concepts of reliability thus operationally defined is objectionable. The score on the test is a numerically defined judgment of the extent to which the subjects accept the suggestion of inability to close the hand (hand rigidity) and the extent to which they accept the suggestion that the hand rises of itself from the table on which it is placed. Since it is the accuracy of these judgments on the part of an experimenter which constitutes the reliability of the tests, a more defensible operational definition would seem to be the extent to which two experimenters judging the responses independently of each other agree in their judgments. It is in this sense that the term reliability is employed in the present study.

B. SUBJECTS AND EXPERIMENTAL PROCEDURE

The subjects were 118 school children in Grades 5 to 7 of whom 56 were boys and 62 girls.[2] The children were brought into the laboratory one at a time and were given the same instructions in the case of each test as given by Aveling and Hargreaves. For the hand levitation test these were as follows:

> "Place your hand on the table, so." *(Subject, facing experimenter, placed his right hand, palm down, upon the table.)* "I am going to lay my hand lightly on top of yours and I want you to pay very special attention to the feelings you get from your hand. You need not tell me anything about them unless I ask you. I just want you to get the feel of them." *The experimenter then laid his hand firmly, but lightly upon that of the subject, so that the tips of his fingers rested upon its back near the wrist. He continued the instruction:* "You will feel your hand growing lighter, as if it was losing weight, and not resting on the table. It gets lighter still now, as if it had no weight at all. Do you feel it?" *If the subject answered,* "No," *the instruction was continued in the same sense; if,*

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[2] It is a pleasure to acknowledge the coöperation of Mr. F. A. Burtsfield, Superintendent of Schools, West Lafayette, Indiana, in providing a laboratory for the experiment and in making the children available for the study.

> "Yes," *the experimenter almost imperceptibly raised his hand, relaxing the very slight pressure and at the same time saying* "Good! it is quite light now. It has no weight at all. It is leaving the table altogether—coming right off of it and rising in the air."
>
> *During the hand rigidity test the subject is seated opposite the experimenter and given the following instructions:* "Hold out your hand—so, like mine, and fix your eyes on my hand. Whatever I say, do not take your eyes off my hand. But, while looking at my hand all the time, I want you to pay special attention to the *feelings* you get in your own. Do you understand? You are to look at my hand all the time. Don't look at your own or at me; but pay attention to the feel of your own hand." *During this general instruction the experimenter held out his hand, palm uppermost, easily and loosely, with the fingers very slightly flexed, in a position some four inches above his right knee, so that the subject could easily fixate it. The instruction then continued.* "You will probably feel a slight tingling, or tightening or stiffening in your fingers. I want you to tell me *at once* when you feel this." *The moment any such feeling was reported the stop watch was started; and the experimenter at the same time deliberately straightening out his fingers and very slowly making his hand stiff and rigid, continued:* "Now! You will find that tingling and stiffening increase, so that your hand becomes *quite* stiff; so that you can't bend your fingers at all; or close your hand. Do you feel it? It's getting stiffer now—quite stiff and rigid. Now you can't move your fingers. You can't *close* your hand. You can't close it at all. Try!"

The two experimenters each tested half the children in double fatigue order, i.e., according to the schema:

Experimenter	*Subjects*
1	1 and 2, 5 and 6, 9 and 10, etc
2	3 and 4, 7 and 8, 11 and 12, etc

A few children were first tested to familiarize the experimenters thoroughly with the procedure. These were not included in the data.

C. Results and Discussion

The major problem, i.e., the psychological uniqueness or generality of suggestibility as measured by the two tests in question is answered quite unequivocally. The correlations given below (Table 1) provide the necessary data.

TABLE 1

INTERCORRELATION AND RELIABILITIES OF HAND RIGIDITY AND HAND LEVITATION TESTS

	r	*N*	Corrected for attenuation
Hand rigidity *vs* levitation	.488±.047	118	.516±.046
Reliability, rigidity, Cutler *vs* Jones	.947±.006	118	
Reliability levitation, Cutler *vs* Jones	.944±.007	118	

It is apparent that, while there is some degree of psychological concomitance of the two variables, their uniqueness or specificity is greater than their overlap. Suggestibility of children so far as these data go, is not a general trait, but in large part specific to the situation.

Data were obtained bearing upon a number of subsidiary problems. The first of these concerns sex differences in the experimental subjects. Table 2 shows the results.

TABLE 2

AVERAGE SEX DIFFERENCES IN SUGGESTIBILITY

		N	Mean	*SD*	PE_M	Diff of means	*Diff* / PE_{diff}	Chances in 100 of a true diff
Hand rigidity	Boys	56	8.43	4.14	0.37	0.37±.49	0.76	69
	Girls	62	8.06	3.73	0.32			
Hand levitation	Boys	56	4.32	2.35	0.21	0.86±.30	2.87	97
	Girls	62	5.18	2.57	0.22			

There is here no clear evidence of a sex difference, although the results for hand levitation approach fairly closely the criterion of a statistically significant difference. The experimenters, before the data were analyzed, reported a subjective impression that boys seemed on the whole more suggestible than girls. The results give some slight warrant for this impression. Since the experimenters were both women and since Aveling and Hargreaves (p. 58) reported girls considerably more suggestible than boys, there is ground for the hypothesis that the sex of the experimenter may be a significant variable in the test situation.

Another problem which presented itself was the differential influence of the two experimenters on the test results. The analysis of this influence is summarized in Table 3.

TABLE 3

AVERAGE DIFFERENCES IN SUGGESTIBILITY FOR THE TWO EXPERIMENTERS

		N	Mean	SD	PE_M	Diff. of means	$\frac{Diff}{PE_{diff}}$	Chances in 100 of a true diff.
Hand rigidity	Jones	62	8.73	3.93	0.34	1.02±.49	2.08	91
	Cutler	56	7.71	3.91	0.35			
Hand levitation	Jones	62	5.53	2.50	0.21	1.58±.29	5.45	100
	Cutler	56	3.95	2.23	0.20			

It is obvious from these results that the children's responses varied on the average with the experimenter. While the average difference for the hand rigidity test is not completely reliable from a statistical standpoint, it is fairly large, and the average differences for both tests are in the same direction. More or less subtle differences in personal appearance, voice, etc., of the experimenter will evidently influence the responses of the subjects in a systematic fashion.

When the collection of the experimental data was nearly finished, the experimenters reported that in their judgment they obtained more positive results as the experiment progressed, possibly as a result of greater practice and familiarity of the experimenters with the technique of administering the tests, possibly also because of the "mental set" of the children who learned from children previously tested something about the nature of the tests. These two possible factors could not be separately evaluated from the data, but that one or both operated is fairly clear from Table 4, in which the first

TABLE 4

COMPARISON OF FIRST HALF WITH LAST HALF OF CHILDREN TESTED

		N	Mean	SD	PE_M	Diff. of means	$\frac{Diff}{PE_{diff}}$	Chances in 100 of a true diff.
Hand rigidity	First half	59	8.42	3.44	0.30	0.81±.48	0.81	71
	Second half	59	8.03	4.38	0.38			
Hand levitation	First half	59	5.54	2.39	0.21	1.54±.30	5.13	100
	Second half	59	4.00	2.37	0.21			

half of the pupils tested are compared with the last half. Although one of the differences is not completely reliable, both differences are in favor of the last half To isolate the two factors it would be necessary to obtain subjects who could not communicate with each other during the progress of the experiment.

One other factor, overlapping the two just mentioned, was introduced during the experiment. The experimenters observed that in the levitation test the subject's hand when placed flat on the polished surface of the desk tended to perspire and stick to the desk. Accordingly a pillow on the experimenter's lap was used for a part of the experiment. That this change measurably increased the scores may be seen from Table 5. Even though the samplings are small and the errors of sampling therefore correspondingly large, the mean difference is practically completely reliable. In absolute amount of score values it is approximately one half the standard deviation of the "raw" scores

TABLE 5

COMPARISON OF AVERAGE SCORES IN HAND LEVITATION FOR TWO TYPES OF SURFACES

	N	*Mean*	*SD*	PE_M	Diff. of *means*	$\frac{Diff.}{PE_{diff}}$	Chances in 100 of a *true diff*
Without pillow	18	4.72	2.33	0.20	1.04±.28	3.71	99
With pillow	41	3.68	2.32	0.20			

D. SUMMARY AND CONCLUSIONS

A group of 56 boys and 62 girls of average age 12 in Grades 5 to 7 were tested for waking suggestibility in terms of a test of suggested hand rigidity and suggested hand levitation to determine the psychological concomitance and uniqueness of the functions in question and to determine the reliability of the measurements according to a more defensible operational criterion than that used in an earlier study by Aveling and Hargreaves. The data support the following conclusions.

1. The functions measured by the two tests are more unique and independent than concomitant (estimated true $r = .516 \pm .046$).
2. Waking suggestibility as defined by these two tests is a function of a number of factors among which probably are the sex of

the experimenter, sex of the subject, "personality" characteristics of the experimenter, the physical conditions of the laboratory situation, social stimulation of the subjects, and the like.

3. The function measured by the two tests were measured with a high degree of reliability, yielding reliability coefficients under the experimental conditions described of the order of .95.

REFERENCE

1. AVELING, F., & HARGREAVES, H. L. Suggestibility with and without prestige in children *Brit J. Psychol.*, 1921, 12, 53-75.

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Purdue University
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GENITAL AND SPHINCTER BEHAVIOR OF THE MALE INFANT*

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A. INTRODUCTION: THE PROBLEM

The frequent occurrence of penial tumescence (*T*) in male infants in hampering situations at feeding time (13) raises several interesting questions. Two of these questions are: With what frequency does *T* occur in the normal daily life of infants? Do other forms of hampering produce this phenomenon? Although the fact that *T* occurs early in life is well established (1, 3, 6, 9, 13, 20), there is no definite information concerning either the frequency of its occurrence or the conditions which produce it. It is possible that in attempting to answer the first of these questions, information may be obtained concerning the conditions which cause *T*.

B. PROCEDURE AND MANNER OF RECORDING

The purpose of the present study was not only to observe and register in order every instance of *T* which occurred during the daily life of male infants, but as far as possible to keep a continuous record of the principal forms of physical and emotional behavior exhibited by the infants. To this end, the names of the infants in crib order were listed in the left hand column of specially prepared charts (see Figure 1) and the behavior of each infant in the order in which it occurred was recorded opposite his name from left to right. Vertical time lines in 5-minute intervals enabled the investigator to keep a fairly accurate account of the concurrent behavior of the infants.

The study was conducted on nine male infants occupying cribs in a single large room. The infants, completely undressed, lay on their backs[1] with diapers spread out smoothly beneath their buttocks and

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[1] No attempt was made to maintain the supine posture. Two of the infants, *C* and *Mi*, usually slept on their left sides. None of them rolled completely over.

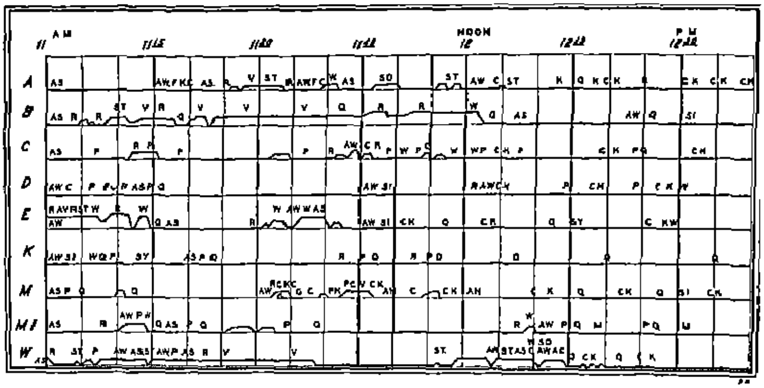

FIGURE 1

Method of Recording Behavior

Behavior shown above occurred on eighth day between 11 00 A M and 12 40 P M

legs. The cribs were arranged in a semicircular row with their feet toward the investigator who stood at a distance of about eight feet from the middle crib so that he could easily observe the movements of the infants. Three assistants who attended the infants aided the investigator in collecting the data which included the following items: angry, arching, asleep, awake, crying, fretting, grasping penis or scrotum, kicking, raising the legs, mouthing, playing, thumb sucking, quiet, restless, feeding, sleepy, moving slowly, soiling, stretching, threshing, twisting, voiding, tumescence and detumescence (*D*). *D* is used to signify the process of subsidence of turgidity in the penis. All of these items were conveniently abbreviated for purposes of tabulation[2]

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[2] *Explanation of symbols* Onset of tumescence (*T*) is indicated by an upstroke (/) from the base line, detumescence (*D*) by a downstroke (\\), and the duration of *T* by the horizontal distance between the upstroke and the downstroke

A	Arches back
AN	Angry
AS	Asleep
AW	Awake
C	Cries
F	Frets
G	Grasps penis or scrotum
K	Kicks
M	Moves about
P	Sucks thumb
Q	Quiet
R	Restless
SL	Slow movements of arms and legs
SO	Soils
ST	Stretches
Sy	Sleepy
V	Penial vibration
W	Voids

Detumescence (*D*) and *T* were recorded as follows Absence of *T* was indicated by a line superposed on the horizontal base line for each infant (see Figure 1). When *T* began a line was drawn upward from the base to show the time (indicated by a clock on the wall in front of the investigator) of the onset of the phenomenon When turgescence had attained its maximum, the line was continued parallel to the base until D set in, when the line was drawn downward toward the base Thus a fairly accurate record of the duration of each T and the time at which it occurred was obtained Increases and decreases in turgescence were indicated in similar manner.

The investigation covered 10 days, from July 6 to July 16, 1937 Observations began at 8 30 in the morning and on eight days continued throughout the day until 5 o'clock in the afternoon The presence of visitors on the fifth day and a drop in temperature on the ninth day terminated the observations for these two days at 3 o'clock. Feeding times throughout day and night were 9, 1, and 5 o'clock. In addition, some form of fruit juice was given at 3 o'clock in the afternoon

1 *The Subjects*

The subjects for the study were a non-selected group of white infants of mixed racial stock in the baby hospital at the State Farm for Women at Niantic, Connecticut.[3] They were of differing weights and body lengths. Only one infant, *B*, was undernourished All of the infants were circumcised. They varied in age from 3 to 20 weeks.

C. RESULTS[4]

1 *Number of T's and Their Distribution*

The total number of *T*'s observed during the 10-day period was 1,663 (Table 1) Sometimes they occurred singly for the individual; more frequently, however, two or more *T*'s followed one another in close succession to form a series. For this reason it seemed advisable not to regard all *T*'s as isolated items of behavior, but to

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[3] The writer is particularly indebted to Miss Elizabeth Munger, Superintendent, Miss Elsie Shearer, Assistant Superintendent, and Miss Edna Wright, Supervising Nurse, for their cooperation in conducting the study.

[4] The results are summarized in eleven tables, reproduced in the text An additional table which details the quantitative data for each individual infant can be supplied by the writer on request

TABLE 1

NUMBER OF *T*'S, OF SERIES OF *T*'S, OF ISOLATED *T*'S; MEDIAN NUMBER OF *T*'S, AND THE RANGE OF THE NUMBER OF *T*'S PER DAY OVER THE 10-DAY PERIOD

Infant	Age in weeks	No of *T*'s	Median No. of *T*'s per day	Range of the No of *T*'s per day over 10-day period	No of series of *T*'s	Median No of series per day	Range of the No of series per day over 10-day period	No. of isolated *T*'s
A	3	330	32	17-44	98	11	5-14	33
B	9	132	14	0-26	55	5	0- 9	23
C	17	89	8	1-20	42	4	1- 7	23
D	18	52	4	0-18	31	3	0- 8	18
E	11	288	29	12-36	94	10	3-12	41
K	20	126	12	5-19	75	8	4-10	48
M	15	172	17	4-26	75	8	4-10	37
M_1	15	99	9	4-21	61	6	3- 8	41
W	6	375	35	11-67	105	11	8-14	37
Totals		1663			636			301

group them in accordance with their occurrence in the individuals. When, therefore, after a careful study of the situation, the interval between successive *T*'s was less than 10 minutes, they were arbitrarily designated as a series In passing it was noted that the turgidity of the congested organ frequently diminished and increased several times during a single *T*. At other times vibratory movements (*V*) of the organ occurred which had no connection with the respiratory rate. In order that all *T*'s might be included in the total number of series of *T*'s, each isolated *T* was regarded as a series. Hence, of the 636 series of *T* listed in Table 1, 301 were instances of isolated *T*'s The remaining series consisted of 2 to 20 *T*'s. When several *T*'s constituted a series, they frequently appeared and disappeared in fairly rapid succession. When only one *T* occurred in a series, it sometimes lasted for many minutes. In fact, in two such cases (*B* and *M*) the duration of *T* was 65 and 66 minutes respectively.

The number of *T*'s and series of *T*'s for the individual infants varied considerably.[5] In general, the younger infants experienced more *T*'s than did the older ones. For example, *D* had only 52 *T*'s in 31 series, while *W* had 375 *T*'s in 105 series. There was no evidence of *T* by *B* on the second day or by *D* on the first two days. The number of *T*'s per day for each individual and for all infants also varied greatly, as Table 1 shows. The smallest number of *T*'s was observed for *D*, *C*, and *M*, the greatest number for *W* and *A* Of the total number of *T*'s per individual, *M* had the greatest number of isolated *T*'s, *W* and *A*, the least number.

Figure 2 gives the distribution of *T*'s throughout the day for the entire period of observation. It has already been noted that observations ceased at 3 o'clock on two days. Of the total of 636 series of *T*'s, 371 occurred during the morning period of 4½ hours and 265 during the afternoon period of four hours Elimination of the two incomplete days leaves the count at 278 series for the morning and 234 for the afternoon. If the nine series in the half hour preceding the morning feeding are omitted, comparable records of the number of series for the morning and afternoon sessions show 269 for the former and 234 for the latter period

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[5] Individual differences were marked The records show that *B* and *M* usually had few *T*'s per series, but they were of long duration, while *A* and *W* generally experienced many transient *T*'s per series

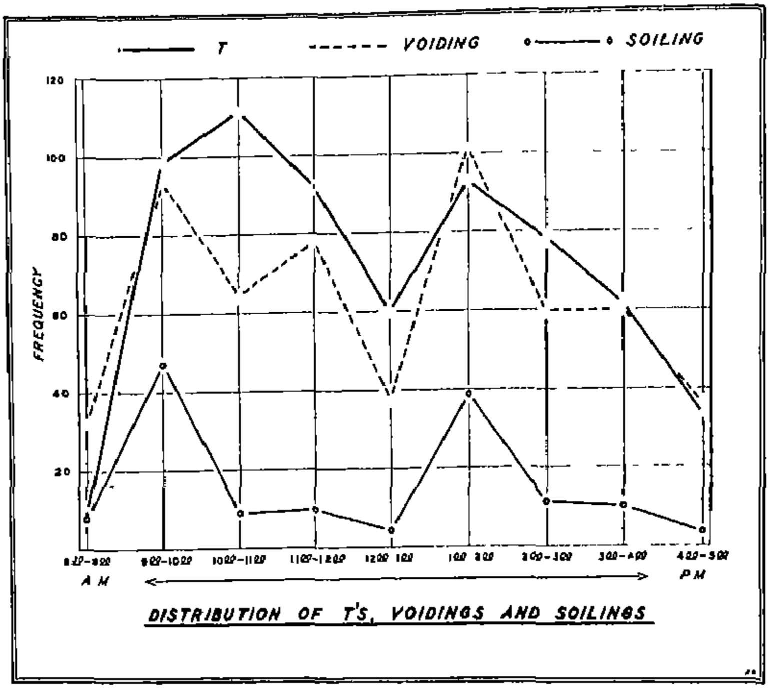

FIGURE 2

Distribution of *T*'s, Voidings, and Soilings from 8 30 a m to 5 p m Over the 10-Day Period

Infants were fed at 9 00 a.m., 1 00 p m. and 5:00 p m.

According to Figure 2, the distribution of series of *T*'s is as follows

Morning		*Afternoon*	
8 30- 9 00	9		
9 00-10 00	99	1 00-2 00	93
10 00-11 00	111	2 00-3 00	77
11 .00-12 .00	92	3 ·00-4 00	62
12 .00- 1 00	60	4:00-5 .00	33

Thus, for both morning and afternoon periods, *T* occurred with greater frequency during each of the first three hours after feeding than during the fourth hour. In the morning period there was a slight rise in the number of series from the first to the second hour, followed by a fall during the third hour. In the afternoon there was a gradual decrease in the number of series from the first hour to the fourth hour. In this connection, it is of interest to note that the distribution of the series of *T*'s throughout the day corresponds rather closely with the distribution of micturitions (see Figure 2)

T occurred when the infants were asleep as well as when they were awake. In fact, of the 636 series of *T*'s observed, 270 (or about 3/7 of all series) occurred during sleep; while 366 occurred during wakefulness On nearly all occasions the presence of the phenomenon during sleep was attended by recurrent periods of stirring or restlessness[6] which in 111 instances (or 41 per cent of the cases) resulted in awakening the infants. The frequency of awakening with *T* varied greatly among the 9 infants *W*, for example, who experienced 50 series of *T*'s during sleep, was awakened on 31 occasions. On the other hand, *A* who experienced 61 series of *T*'s during sleep, was awakened only eight times In most instances infants awoke with a start Frequently the startle was severe enough to produce crying Three of the infants, *A*, *B*, and *D*, experienced more *T*'s during sleep than during wakefulness.

2 *Duration of T*

Although it was not always possible to determine the exact time at which a *T* began or ended, the procedure adopted was to record *T* only when its presence was a certainty No attempt was made to record the duration of *T* in intervals less than 30 seconds. For example, a *T* lasting 2 minutes 25 seconds was recorded as of 2.5 minutes duration, a *T* of 2 minutes 10 seconds was recorded as of 2 minutes duration. A very short *T* of any duration less than 30 seconds was given a rating of 0 5 minutes. Intervals separating the *T*'s of a series were not subtracted from the durational time of the series unless the intervals were greater than 45 seconds.

Table 2 summarizes some of the durational aspects of *T* for each of the subjects, viz., total duration of all series of *T*'s, range of duration of the individual series of *T*'s throughout the 10-day

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[6] Stirring in this case includes those slight movements which only momentarily affect the posture of the infant Restlessness signifies an increase in general activity and refers to the greater movements, viz, drawing up the legs, twisting, rolling, etc, which result in changes in posture and position

TABLE 2

DURATIONAL ASPECTS OF *T* FOR THE 10-DAY PERIOD

Infant	No. of series of *T*'s	Duration of all series of *T*'s *Min.*	Range of duration of *T* for the individual days *Min.*	Av. duration of series of *T*'s *Min*	Duration of all series of *T*'s in % of total observation time	Time range of individual *T*'s *Min*
A	98	492.0	15.5- 88.5	5.0	9.6	0.5-19
B	55	757.0	0 -147.5	13.8	14.8	0.5-65
C	42	247.5	0.5- 79.0	5.9	4.9	0.5-21
D	31	161.0	0 - 47.5	5.2	3.2	0.5-32
E	94	783.5	31.0-139.0	8.3	15.4	0.5-51
K	75	354.5	10.0- 82.5	4.7	7.0	0.5-26
M	75	1,084.5	15.0-272.5	14.5	21.3	0.5-66
Mi	61	143.5	4.5- 25.5	2.4	2.8	0.5- 7
W	105	858.0	27.5-191.5	8.2	16.8	0.5-38

period, average duration of these series, percentage of total time during which *T* was present, and time range of individual *T*'s The total number of series of *T*'s is also given. The total duration of all *T*'s for the 10-day period varied from 143.5 minutes for *D* to 1,084 5 minutes for *M*. Although *W*, *A*, and *E* experienced more *T*'s than did *M* (see Table 1), the latter's *T*'s were usually of long duration and were the cause of considerable annoyance to him On several occasions they startled him awake and evoked strong crying. On other occasions he repeatedly reached for his penis and scrotum and grasped or clawed them violently. No one who observed *M* at these times could doubt the source of his irritation *Mi* was least disturbed by *T*. Although 61 series were reported, his *T*'s were always of short duration and usually preceded micturition.

The duration of *T* varied greatly from day to day for the individual subjects as the range of duration shows. *T* was experienced every day by seven of the nine infants *B*, *E*, *M*, and *W* passed from one extreme to the other with respect to the duration of *T* series. The average duration shows that the longest series of *T*'s were experienced by *M* and *B*, the shortest by *Mi* and *D*. The table shows that in *M*'s case, *T* was present for about 1/5 of the total observation time, and in *Mi*'s case, for less than 1/33 of the time *T* occupied considerable time also for *W*, *E*, and *B* and only a small amount of time for *D* and *C*. All subjects at times experienced *T* for very short intervals, i.e , 0.5 minute or less.

The time elapsing between the onset of successive series of *T*'s for the 10-day period is shown in Table 3.[7] The median time for the individual subjects varied from 25 minutes for *A* to 65 minutes for *C*, when all series were taken into account Inasmuch as the time

TABLE 3

TIME ELAPSING BETWEEN ONSETS OF SUCCESSIVE SERIES OF *T*'S

Subjects	*A*	*B*	*C*	*D*	*E*	*K*	*M*	*Mi*	*W*
Median (min)	25	60	65	60	40	40	45	45	35
Range (min)	10-230	15-245	10-235	10-260	10-210	10-210	10-320	10-180	10-180
No of series	88	45	32	24	84	65	65	51	95

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[7] The days on which *B* and *D* experienced no *T*'s were omitted in this instance

between the successive series was usually greatest at mid-day, when the infant was fed, the omission of the period between the last *T* before this feeding and the first *T* after the feeding usually reduced the time elapsing between series. In *B*'s case, the time was reduced as much as 15 minutes There was no reduction of time for *A* or *W*. The range of elapsed time between successive series shows that on occasions only 10 to 15 minutes separated the onsets of successive series and that on other occasions this interval was as much as 180 to 320 minutes for all series of *T*'s and 90 to 210 minutes with the elimination of the noon period.

3 *Behavior During T*

The behavior of the infants during *T* varied considerably. Most of the infants were greatly disturbed by it on several occasions Two of the infants were definitely emotionally upset on all occasions, whereas two others manifested only a high degree of restlessness during periods of *T*. The principal types of behavior and the frequency of their occurrence are shown below Two or more of these activities frequently occurred concurrently. In all such cases the outstanding behavior is the one listed, although all were recorded.

Behavior during *T*	Frequency of occurrence
Quiet (includes stirring)	91
Restless	242
Stretching	72
Flexing legs stiffly	97
Thumb sucking	5
Fretting	18
Crying	111

4. *Situations in Which T Occurs*

Table 4 shows the number of series of *T*'s the range of the individual medians of number of *T*'s per series, minimum and maximum number of *T*'s per series, and total number of *T*'s associated with micturition, defecation, concurrent micturition and defecation, waiting for the bottle, and non-specific situations. The last category was necessary because a great number of *T*'s defied specific classification. They occurred in situations which *apparently had no connection* with either of the first four categories. They sometimes occurred several minutes after *voiding and were not followed by* soiling or further voiding of the bladder They sometimes occurred between voidings, between voiding and soiling, and between soiling and voiding. They

TABLE 4

No of Series of *T*'s, Median No of *T*'s per Series, Range of the No of *T*'s per Series, and Total No. of *T*'s, Associated with Micturition, Defecation, Concurrent Micturition and Defecation, Waiting for the Bottle, and Non-Specific Situations

	Micturition	Defecation	Concurrent micturation and defecation	Waiting for bottle	Non-specific situations
No. of series of *T*'s	300	42	34	27	233
Range of the individual medians of the No of *T*'s per series	1- 3	1- 6	1- 2	0- 2	1- 3
Minimum and maximum No of *T*'s per series	1-17	1-13	1-10	1-20	1-12
Total No of *T*'s	831	120	63	68	581

occurred in wakefulness and in sleep, in restlessness and in quiescence, during crying and smiling, and during strong and mild bodily activity.

The order of the situations with respect to frequency of the occurrence of *T* series is micturition, non-specific situations, defecation, micturition and defecation, and waiting for bottle Thus, more *T*'s were associated with micturition than with any other situation listed in the table. In fact, the frequency with which the two occurred together led the observers to expect voiding of the bladder whenever *T* was present The number of such *T* series varied from 15 for *D* to 60 for *E* Individual differences were outstanding

The number of *T* series associated with defecation totals 42, over half of which were accounted for by *A* and *W* (see Table 8). The number associated with concurrent defecation and micturition was 34, *one-third of which were experienced by W.* Thus, although frequency of *T* at defecation varied greatly among the infants, each experienced a *T* upon at least one occasion, and the same is true for concurrent defecation and micturition.

T occurred on 27 occasions when infants waited for the bottle or lost the nipple during feeding. However, micturition or defecation also occurred on three of these occasions during the waiting period, and on five occasions during feeding. For the remaining 19 *T*'s, voiding or soiling occurred as follows eight within 15 minutes after feeding, four within 45 minutes, and seven within 75 minutes. Thus the excitement attending waiting may not have been the sole contributing factor to *T*. The situation at best is complicated (13). The number of *T*'s in his situation varies from none for *Mi*, the most docile infant, to seven for *M*, the most irritable infant.

There were 233 series of *T*'s which could not be definitely connected with voiding, soiling, or waiting for food. All infants experienced *T*'s in these non-specific situations In frequency of occurrence the number of series varied from 9 for *D* to 46 for *A*. These apparently miscellaneous *T*'s were as persistent as those associated with voiding and caused equally as much irritation and restlessness.

The total number of *T*'s for each of the five situations was: micturition, 831, defecation, 120; micturition and defecation, 63; waiting for food, 68, and non-specific situation, 581. Thus 50 per cent of all *T*'s were associated with voiding, about 4 per cent with concurrent voiding and soiling, 7 per cent with soiling, 4 per cent with waiting for food, and 35 per cent with non-specific situations.

In general the infants who had the greatest total number of *T*'s in any situation had the greatest number of series of *T*'s and also the greatest variation in the number of *T*'s per single situation. The median number of *T*'s per single situation indicates that there were more *T*'s per micturition than for any other single specific situation

The number of series of *T*'s occurring during wakefulness in all situations was greater than the number occurring during sleep. In the non-specific situations, however, the number of series of *T*'s occurring during wakefulness was less than the number occurring during sleep Of the 124 series occurring during sleep in the non-specific situations, 33 were sufficiently disturbing to awaken the infant. Although every infant was awakened from sleep at least once, *A*, *B*, and *C* were less disturbed by the presence of *T* than were the other infants. Five of the infants experienced more *T*'s during sleep than during waking hours. When the specific and non-specific situations were compared, it was found that the series of *T*'s were distributed as follows.

All situations.	awake 366;	asleep 159;	awakened 111
Non-specific situations:	awake 109,	asleep 91,	awakened 33
Specific situations	awake 257;	asleep 68,	awakened 78

Thus, whereas infants were awakened from sleep during *T* in only 27 per cent of the cases in the non-specific situations, they were awakened in 53 per cent of the cases in the specific situations. This difference is undoubtedly due to the fact that in the specific situations, voiding or soiling accompanied *T*.

5. *Voiding*

a *Voiding and T.* It is often impossible to determine the frequency of voiding by observing the condition of the diapers. The amount of urine passed during a single micturition may be large or small When the interval between voidings is short, the amount of urine passed is usually small, when the intervals are long, the amount passed is correspondingly large. During *T* as few as one to four drops occasionally comprise the total amount of urine passed at one time.[8] The voiding of so small an amount of urine and the presence of *T* both go unnoticed when the infant is clad in diapers.

Table 5 shows that of a total of 564 micturitions during the 10-day period of observation, 342 occurred in the presence of *T*, and 222 in its absence. The number of micturitions per infant varies from 45 to 88 *It is noteworthy that seven of the nine infants had more*

TABLE 5

TOTAL NO. OF MICTURITIONS BY EACH INFANT
(Includes micturitions which occurred with defecation)

Subjects Age in weeks	*A* 3	*B* 9	*C* 17	*D* 18	*E* 11	*K* 20	*M* 15	*Mr* 15	*W* 6	All infants
Micturitions with T	38[1]	28[2]	17[3]	14[1]	71[4]	46[5]	41[6]	35	52	342
Micturitions without *T*	17	18	36	31	17	40	21	30	12	222
Total No.	55	46	53	45	88	86	62	65	64	564

[1] In one instance voiding occurred just after *T*

[2] In one instance voiding and soiling occurred again five minutes later.

[3] In four instances voiding occurred just after *T*.

[4] In one instance the infant voided five times in succession during a *T*; in two instances he voided twice during a series of quick *T*'s; in another instance he voided three times in one series, and in still another instance he voided just after *T*.

[5] In two instances the infant voided three times during a single series of *T*'s, and in another instance he voided twice during one *T*

[6] In one instance two voidings occurred during a single *T*

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[8] Infants frequently pass small amounts of urine during *T*. This was particularly true of *E* and *K* In *K*'s case, urine occasionally spurted forth in drops the number of which could usually be counted

micturitions with *T* than without *T* In fact for two of these infants, the number of micturitions without *T* was less than 25 per cent of the number with *T*. *On the other hand, for the two remaining infants the number of micturitions without T was more than double the number with T* It may be concluded then that under the conditions of this study there are individual differences in the frequency with which T attends micturition. The table shows that *there is little, if any, correspondence between age and* frequency of micturition.

The explanatory notes accompanying the table reveal further interesting facts concerning micturition and *T*. For example, infants frequently urinate more than once during a series of *T*'s In other words, inasmuch as the bladder was not completely voided on the first micturition, sufficient urine remained in this organ to evoke not only further desire for voiding, but probably the additional *T*'s. After incomplete voiding, *T* may continue until voiding again takes place, or *D* may occur and be followed by another, or several, *T*'s until the bladder is finally emptied, or *D* may occur and be followed by voiding without further *T* Frequently a single *T* is followed by D just before voiding takes place. Occasionally when voiding occurs during *T*, soiling and further voiding follow during the subsequent *D*. Further observations reveal the following facts: *Micturition may be anticipated by a single T of long or short dura*tion, or by a succession of *T*'s; *T* may attain a state of partial or complete engorgement and remain in this state until micturition or defecation occur; or it may fluctuate in amount of engorgement. Complete engorgement is usually attended by penial vibrations

b Distribution of micturitions during the day The hourly distribution of micturition with and without *T*, shown in Figure 2, was as given in Table 5*a*.

Although it was quite impossible to predict just when voiding would take place, the act occurred with great frequency during the hour after feeding began, with somewhat less frequency during each of the two succeeding hours, and only occasionally during the hour preceding the next feeding.

Over 70 per cent of the micturitions occurring between 10 and 1 o'clock and between 2 and 3 o'clock were attended by *T*, whereas the percentage of micturitions with *T* during *the hours of 9 to 10*, 1 to 2, 3 to 4, and 4 to 5 was 63, 53, 53, and 54 respectively. When

TABLE 5*a*

	With *T*	Without *T*	Total
A.M. 8:30- 9:00	2	30	32
9:00-10:00	59	34	93
10:00-11:00	47	18	65
11:00-12:00	55	23	78
M. 12:00- 1:00	29	9	38
P.M. 1:00- 2:00	54	47	101
2:00- 3:00	44	16	60
3:00- 4:00	32	28	60
4:00- 5:00	20	17	37
Totals	342	222	564

the morning and afternoon sessions, exclusive of the 8:30 to 9 o'clock period, were combined, it was found that 58 per cent of the micturitions which occurred during the first hour after the start of feeding were attended by *T*. The percentage of micturitions attended by *T* during the succeeding hours was: second hour, 73, third hour, 63, and fourth hour, 65. Hence the number of micturitions with *T* was proportionately greatest during the second hour and least during the first hour after feeding. It will be noted that the voidings without *T* greatly outnumber the voidings with *T* at the pre-feeding period in the morning.

c. Time between micturitions. The time elapsing between micturitions (see Table 6) as indicated by the medians varied greatly for the individual subjects from 35 minutes for *E* to 100 minutes for *D*. (*All computations were in terms of intervals of five minutes.* Intervals of less than five minutes were given a 5-minute rating.) The median time of all the medians for the group was 65 minutes. Time intervals between micturitions for each of the subjects also varied considerably. The elapsed time ranged from 5 to 170 minutes

TABLE 6

TIME ELAPSING BETWEEN MICTURITIONS

Subjects	*A*	*B*	*C*	*D*	*E*	*K*	*M*	*Mi*	*W*
Median time in min.	65	75	70	100	35	45	65	60	50
Range in min.	10-235	20-285	5-250	15-265	5-170	5-175	5-245	5-215	5-285
No. of intervals	45	36	43	35	78	76	52	55	54

for *E* who voided frequently, from 15 to 265 minutes for *D* who had the fewest number of micturitions, and from 5 to 285 minutes for *W* whose intervals between micturitions varied greatly in time These figures indicate that the infants sometimes went for hours without urinating and at other times passed small amounts of urine at irregular short time intervals. *E* and *K*, for example, at times urinated four or five times within half an hour On the other hand, *D* seldom urinated twice within an hour's time. *B*, *C*, *M*, and *Mi* also retained urine for long intervals

Intervals between micturitions frequently exceeded 100 minutes. The number of such intervals which varied from 8 each for *B* and *E* to 17 each for *D* and *Mi*, totaled 117. Intervals of 20 minutes or less between micturitions were also of frequent occurrence. The number varied from 2 for *D* to 21 for *K*, and totaled 81.

With the exception of *A* and *W*, there were more micturitions in the morning than in the afternoon, and with the exception of *W* alone, the number of *T*'s was greater for the morning period than for the afternoon period. These differences are in part accounted for by the fact that the morning period is half an hour longer than the afternoon period, and that on two afternoons observations ceased at 3 o'clock.

d. Voiding and sleep. Voiding usually occurred while infants were awake. Of the 564 micturitions recorded, 433 took place during waking life, 81 during sleep, and 50 on awakening. The 50 awakenings occurred during voiding or during the restless interval preparatory to the act. Voiding during sleep disturbed some infants less than others. *D* and *W* were usually awakened just before or during the act On several occasions infants stirred restlessly or momentarily opened their eyes but did not awaken Infants who were sleepy but not asleep at the time micturition occurred, usually dropped asleep after they had voided. On a few occasions, however, the act stimulated them to full wakefulness. It was noted that when *T* during sleep failed to awaken an infant, micturition during *T* usually awakened him with a start.

6. *Soiling and Voiding*

Soiling and voiding frequently took place in close succession. The two acts seldom occurred simultaneously. The records show that either may precede the other, interrupt the other, or start before the first act is completed. At other times these acts were separated by a relatively long time interval, 5 to 15 minutes. For example, after either act occurred unmistakable signs (drawing up of the legs, stiffening, grunting, abdominal movements) that the other act was about to take place were clearly evidenced.

a. Number and distribution of stools throughout the day. Soiling apparently occurs most frequently during feeding or within half an hour after feeding. Figure 3 shows that of a total of 142 stools during the 10 days of observation, 61 were evacuated within half an hour after the start of feeding. The remaining stools were distributed as follows: 25 during the second half-hour; 20 during the second hour; 20 during the third hour, and 8 during the fourth hour

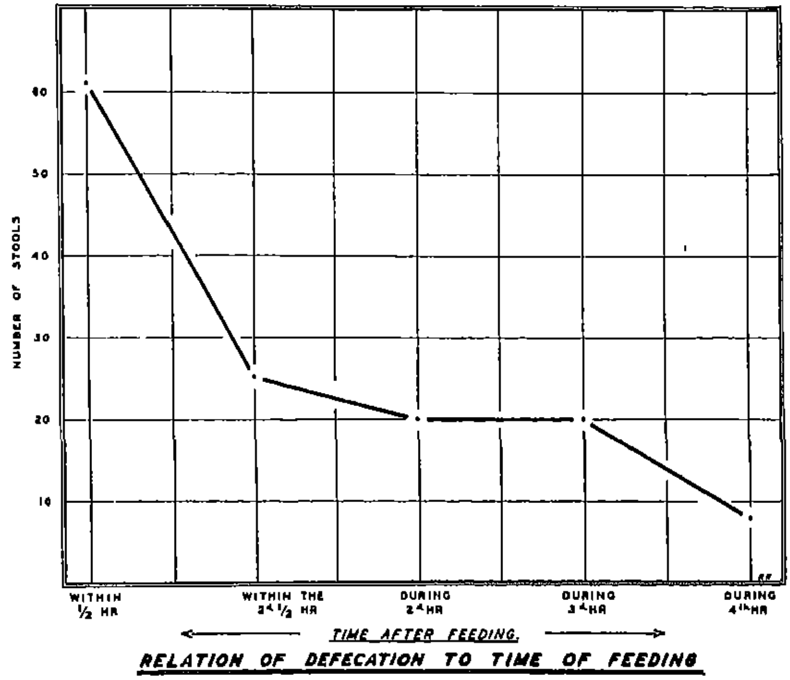

FIGURE 3
Relation of Defecation to Time of Feeding

The remaining eight stools were excreted during the half-hour preceding the 9 o'clock feeding.

Figure 2 and Table 7 show the distribution of stools during

TABLE 7

RELATION OF FREQUENCY OF SOILING TO TIME OF FEEDING
(Feeding times 9, 1, and 5 o'clock)

Time		Soiling only		Soiling and voiding		Total No of stools
		With *T*	Without *T*	With *T*	Without *T*	
A M	8:30- 9:00	1	2	1	4	8
	9:00- 9:30	7	15	4	7	33
	9:30-10:00	4	5	4	1	14
	10:00-11:00	5	0	2	2	9
	11:00-12:00	6	1	1	2	10
M	12:00- 1:00	1	1	1	1	4
P M	1:00- 1:30	3	13	7	5	28
	1:30- 2:00	4	5	2	0	11
	2:00- 3:00	6	0	5	0	11
	3:00- 4:00	4	0	4	1	10
	4:00- 5:00	1	1	2	0	4
Totals		42	43	33	23	142

the day. The number of stools is quite evenly divided between morning and afternoon. There were 48 instances of soiling without voiding in the morning and 37 in the afternoon, one-half of which were attended by *T*. Soiling with voiding occurred 30 times in the morning and 27 times in the afternoon and was attended by *T* in more than half the number of cases. Thus, internal organic conditions preceding the defecatory act are more potent in the production of *T* when the bladder is about to release its contents than when voiding exigency is absent.

Altogether there were 57 instances of concurrent soiling and voiding, 30 (47 per cent) of which occurred within one hour after the start of the feeding period. The number of these associated acts decreased rapidly during the succeeding hours until the time of the next feeding. Of the 85 evacuations in the absence of voiding, 56 (66 per cent) occurred during the hour after the start of feeding.

b Behavior preceding and during soiling. Evacuation usually took place when infants were awake. In fact, 121 defecations occurred during waking life, and only four during sleep. On 17 occasions infants who were asleep awakened just previous to, or during, the act of soiling. At other times they awakened 15 to 30 minutes before the act occurred After soiling they frequently returned to sleep[9] Infants seldom cried when soiling occurred during or soon after feeding Between feeding periods, however, four of the infants (viz, *K, M, Mi,* and *W*) frequently fretted or cried as soiling was about to start General restlessness which usually preceded all soilings was in many instances succeeded by quiescence after the consummation of the act. On many occasions a series of *T*'s also preceded soiling The phenomenon usually disappeared with complete evacuation of the rectum When soiling was not complete, a second and even a third defecatory movement usually occurred within a few minutes, which often was preceded by and frequently accompanied by further *T*. Another peculiarity noted was the frequent voiding of small amounts of urine with or without *T*, preceding defecation The number of stools per individual over the 10-day period varied from 10 for *E*, who was reported on the fifth day as constipated and given an enema, to 28 for *A* (see Table 8).

c. Frequency of voiding and soiling Table 8 gives the total number of micturitions and defecations by each infant during the 10-day period. Of 384 instances in which *T* accompanied these acts, 308 occurred at voiding, 42 at soiling, and 34 at concurrent voiding and soiling. The 265 instances in which these acts occurred without *T* (see Table 9) included 199 voidings, 43 soilings, and 23 concurrent voidings and soilings. Thus, voidings during *T* outnumbered voidings without *T* by 109.

The median number of micturitions per day for the eight complete days of observation varied from 5 to 9 for the individual infants and the range of frequency of voiding per day for all infants was 2 to 15 The frequency of micturition per day for any one infant was far from constant The total number of micturitions for the individual subjects during the eight days ranged from 39 to 73.

The median number of stools per day for the individual infants varied from one to three, the maximum number varied from two defecatory acts took place during the period preceding feeding and three others occurred shortly after *T*.

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[9] Some of the infants displayed irritation after bladder or bowel elimination if the diapers were not at once removed. The practice was to change the diapers after each soiling or voiding When elimination was incomplete, and the infant usually gave evidence of this fact, the diaper was left under the infant until it was fairly certain that the act was finished The substitution of clean diapers usually brought quiescence and frequently sleep (9, p 126)

It has been stated that *T* sometimes occurred soon after voiding or soiling. The records show that there were 71 such *T*'s following voiding and 17 following soiling. On most occasions these *T*'s pertained to the series which accompanied the acts. However, eight voidings and three soilings which occurred without *T* were followed by *T*.

e. Time elapsing since previous feeding, voiding, and soiling of each series of T's. Table 10 shows the time elapsing since feeding, micturition, and defecation of each series of *T*'s experienced by each infant In the instance of feeding, the time was computed from the start of the feeding period in intervals of five minutes. The number of series available in determining the elapsed time since micturition and defecation was in all cases less than the total number of series because micturition and defecation, especially the latter, frequently occurred subsequently to one or more series of *T*'s on most days When no defecaion or no *T* occurred on a given day, no estimate could be made of the elapsed time For example, there were no defecations by *D* on four days, by *M* on three days, by *B* and *E* on two days, and by *C* and *W* on one day. In addition, a defecation by *C* late in an afternoon was not followed by *T*. Furthermore, *D* went two days and *B* one day without *T*. The elapsed time since feeding of each series of *T*'s for the nine infants, as indicated by the

TABLE 10

TIME ELAPSING SINCE PREVIOUS FEEDING, MICTURITION, AND DEFECATION, OF EACH SERIES OF *T*'S

	No of minutes since								
	Feeding			Defecation			Micturition		
Infants	Median	Range	*No. of* series	Median	Range	*No. of* series	Median	Range	*No of* series
A	110	15-240	98	50	5-205	87	85	5-495	81
B	115	25-240	55	40	5-195	50	95	20-485	35
C	140	15-240	42	70	5-180	37	155	30-270	18
D	90	15-215	31	75	10-190	28	165	5-380	18
E	95	5-240	94	35	5-145	86	125	10-390	36
K	85	0-240	75	35	5-130	67	105	10-360	38
M	90	5-240	75	45	10-205	70	175	10-445	40
Mi	105	5-230	61	65	5-180	53	120	5-330	38
W	90	0-240	105	45	5-185	89	110	5-405	98

medians, varies from 85 minutes for K to 140 minutes for C. The range of the individual measures shows that the shortest time elapsing since feeding varies from 0 to 25 minutes for all infants and that the longest time varies from 215 to 240 minutes. Thus T may occur during or very shortly after feeding, or it may not occur until just before, or even after, the next feeding.

In computing the time from micturition to succeeding T's it was noted that two or more series of T's frequently occurred before micturition again took place. The medians for the lapsed time vary from 35 minutes for E and K to 75 minutes for D. The range of the individual measures for all infants varies from 5 minutes to 205 minutes. Thus, for example, one might expect T by B at about 40 minutes after voiding, although there is no guarantee that it will not occur within five minutes or after three hours. In the case of defecation wherein the median time elapsing between this act and T (85-175 minutes), and the range of the measures are both greater than the corresponding measures of the lapsed time between micturition and T, there is again little assurance as to the time relationships of defecation and T.

f. Comparison of time between successive micturitions, time elapsing between micturition and T, and time between successive series of T's. Comparison of the time between successive micturitions and the time between micturition and the subsequent T in individual instances failed to show any clear relation between the two time intervals. Similar comparison of defecation with T proved futile. Several facts may be advanced to explain the apparent lack of relationship between micturition and T. (*a*) On several occasions two or more successive voidings occurred in the absence of T. (*b*) A succession of series of T's frequently occurred between voidings. (*c*) T sometimes occurred between voidings but not immediately before or during the act. (*d*) T did not occur at all during two days for one infant, one day for another infant, and a half day for a third infant. However, these explanations do not alter the fact that in the majority of cases avoiding was attended by T.

Table 11 presents the individual medians for three groups of measures: (*a*) the time between successive micturitions, (*b*) elapsed time between micturition and T, and (*c*) the time between successive series of T's. The rank order from the lowest to the highest median for each of the three groups of measures is also shown. The rank orders of the first two groups of medians reveal that in general infants who have a low median time interval between micturitions also have a low median time interval between micturition and *T*; and that infants with a high median time interval between micturitions, have a correspondingly high median time interval between micturition and *T*. There is also some correspondence between the rank orders of the first and third groups and between the second and third groups. There are of course one or two outstanding inconsistencies in the three groups of rank orders. Note that in general the time between successive micturitions is greater than the time between micturition and *T*, or the time between successive series of *T*'s. The time between micturition and *T* is greater than the time between successive series of T's on five occasions and less on three occasions. Finally, the table reveals interesting constitutional differences between the infants. For example, *D* had long time intervals between *T*'s as well as between voidings, whereas *E* had correspondingly short time intervals in each case. *A* had long time intervals between voidings and very short time intervals between *T*'s.

g. Behavior after voiding and soiling. It has been noted that bodily activity sometimes increased to the point of restlessness as the time for voiding or soiling approached and that at times the period of restlessness preceded these acts by as much as 30 to 65 minutes.

The behavior of the infants after voiding or soiling could not be predicted. If the infant had been awake for some time previous to the time of thorough evacuation of the bladder or colon, he either fell asleep immediately, lay quietly for several minutes and then went to sleep, or played with the side rails of the crib or objects suspended from the side rails. When the infant was already asleep, voiding or soiling generally awakened him. On these occasions he either returned to sleep, remained awake and played, or looked quietly about for some time.

If the infant had been awake for a relatively long time before either of these acts took place, or had been awakened by the act, or precursors of it, and the act was not fully consummated, he remained restlessly or fretfully awake, and even cried or sank into restless sleep from which he occasionally awakened and completed the act.

Altogether the voidings, soilings, and concurrent voidings and soilings number 649. (If the voidings and soilings which occurred concurrently are listed individually, the number is 706.) On 144 occasions infants went to sleep immediately (within five minutes) after either act, on 276 occasions they remained awake and quiet, and on 229 occasions they were awake and restless, fretting or crying. At the end of 15 minutes on 173 occasions the infants were asleep, whereas on 476 occasions they were awake.

7. *Detumescence*

D did not always occur as a result of the elimination of the conditions which appeared to produce *T*. For example, when *T* preceded the act of soiling, *D* did not always occur after evacuation. The phenomenon occasionally disappeared before soiling occurred or remained for some time after evacuation, and disappeared with crying, sucking the thumb, or subsequent voiding. For this reason the number of *T*'s which occurred with soiling (Table 4) are somewhat at variance with the number of *D*'s which followed evacuation. Similar discrepancies appear in comparing the conditions under which other *T*'s occurred and disappeared.

The conditions under which *D* took place in order of their frequency are:

During or after voiding (usually quiescent)	307
Quiescence only	138
Sucking thumb	53
After soiling	37
Crying	33
During or after concurrent voiding and soiling	27
Sucking milk	27
Marked bodily activity	11
Playing	3

Thus, almost 50 per cent of the *D*'s occurred during or after voiding, 6 per cent, during or after soiling, 4 per cent, on concurrent voiding and soiling, and 22 per cent, during quiescence. The remaining *D*'s occurred during the discharge of nervous energy involved in sucking, crying, kicking, playing, etc. With the exception of Infant *A*, voiding was not only more effective than any one other condition in abating *T*, but with four of the infants, *E*, *K*, *M*, and *Mi*, was more effective in this respect than all the other conditions combined. Two of the infants, *A* and *W*, who were relatively as frequently subject to *T* before soiling as before voiding, were just as frequently relieved of *T* through soiling as through voiding.

Quiescence also was an important factor in relieving turgescence with both of these infants *D* frequently occurred during crying in the case of *M*, and during thumb sucking on the part of *B*, *C*, *D*, *K*, and *Mi*

On many occasions the conditions were complicated by the presence of two or more activities, any one of which might have contributed to the abatement of *T* For example, crying was usually accompanied by kicking, twisting, and other physical activities Thumb sucking was carried on with much body movement and occasional fretting Thumb sucking also occurred during voiding on 16 occasions and during soiling on four occasions. In three instances, voiding or soiling took place during feeding. It is of interest to note that in several instances where *T* occurred during crying, restlessness, or thumb sucking, the phenomenon also disappeared during the same activity.

Infants were usually awake or awakened when *D* occurred during or after voiding, soiling, or feeding In some of the other situations, however, they were frequently asleep The number of times they were awake or asleep in the other situations was as given in Table 11*a*.

TABLE 11*a*

	Awake	Awakened	Asleep
Quiescence	50	19	69
Marked bodily activity	3	4	4
Crying	23	10	0
Playing	2	1	0
Sucking thumb	32	7	14

The fact that 58 per cent of the above cases of *D* occurred during quiescence and that 22 per cent occurred during quiet sucking, cannot be ignored Awakening was due to the fact that on occasions turgescence of the penis frequently waned and increased several times *during the course of D and thereby* caused sufficient annoyance to startle the infant. One of the infants so awakened began playing with his doll. In 14 instances infants intermittently sucked at their thumbs as they lay with eyes closed In general, the younger infants were more frequently asleep during *D* than were the older ones.

8. *Crying*

Although crying was of frequent occurrence, the records show that this behavior occupied but a small part of the total observation time.[10] Under the present conditions it was impossible to determine the actual amount of time consumed by crying. There were sustained cries, short cries, screams, and occasionally during *T*, sudden squeals. As far as could be determined, the conditions under which crying took place and the frequency of its occurrence were as follows:

(1)	Waiting for food	109
(2)	During or preceding *T*	168
(3)	Sleepy, but unable to sleep	210
(4)	Before voiding or soiling in the absence of *T*	25
(5)	Failure in getting thumb in mouth or in keeping it there	44
(6)	Losing nipple during feeding	3
(7)	Restlessness (other conditions not determinable)	85

Crying in the first four situations might be ascribed to distress caused by internal organic conditions. In the second situation, during *T*, the infant might also have experienced physical pain. Observations confirm this view. In Situations 5 and 6, and perhaps 3 and 7, crying probably was due to thwarting. It is not unlikely that fatigue was an important factor in Situations 3, 5, and 7.

It was clearly evident that inability to sleep was the outstanding factor contributing to crying. The desire for sleep in all cases was patent. In many instances they succeeded in falling into an unbroken sleep. In other instances wherein sleep occurred, infants were restless throughout, awakened momentarily at irregular intervals, or awakened and did not again sleep until after a subsequent voiding, soiling, or feeding. Those infants who did not succeed in attaining sleep were in most cases irritable. *K* and *Mi*, however, occasionally resorted to playing with their toys. All of the infants, with the exception of *A* and *K*, frequently experienced difficulty in going to sleep.

An arbitrary distribution of the frequency of crying shows that

17 per cent of the crying occurred between 8 30 and 9 10 A.M.
12 per cent of the crying occurred between 9 10 and 11 00
36 per cent of the crying occurred between 11 00 and 1 10
13 per cent of the crying occurred between 1 10 and 4 00
22 per cent of the crying occurred between 4.00 and 5 00 P.M.

Hence, under the conditions of this study, the frequency of crying was greater during (*a*) the half-hour preceding the morning feeding, (*b*) the two hours preceding the noon feeding, and (*c*) the hour preceding the 5 o'clock feeding, than it was during the respective two and three hours following the morning and noon feedings. In this connection it was noted that micturition and defecation were usually accomplished with less difficulty during or immediately after feeding than at other times.

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[10] Bayley (2) found in observations lasting approximately an hour that infant crying took up about 15 per cent of the total examination time.

9. *Individual Differences*

Restlessness was the most common physical accompaniment of *T* for all infants except *M* and *W*. *M* usually cried; *W* either stretched or flexed his legs stiffly, grunted and frequently broke wind. *A* also resorted to stretching on frequent occasions. *B* and *C* frequently cried or flexed the legs, while *D* as a rule exhibited only restlessness. *E*, *K*, and *Mi* usually flexed their legs sharply as *T* increased and on other occasions extended them. Fretting and thumb sucking occurred only infrequently. However, *K* engaged in vigorous thumb sucking on three occasions and *Mi* on two occasions. In addition it was observed that in several instances these two infants were also busily sucking their thumbs during the general restlessness attending the onset of *T*. In general, *E*, *K*, and *M* were most disturbed by the presence of *T*. *E* was very frequently awakened by it, *K* uttered short piercing cries, while *M* kicked and screamed.

Although the number of *T*'s greatly exceeds the number of micturitions (564 throughout the 10 days) the number of series of *T*'s (636) is not much greater than the number of micturitions. Great individual differences appear in the number of micturitions and in the number of *T*'s and the number of series of *T*'s. The number of micturitions varies from 45 for *D* to 88 for *E*, the number of series of *T*'s, from 31 for *D* to 105 for *W*, and the number of *T*'s, from 52 for *D* to 375 for *W*. Thus *D* who voided only 45 times experienced only 31 series of *T*'s and a total of 52 *T*'s throughout the 10 days, while *A* who voided 55 times experienced as many as 98 series of *T*'s and a total of 330 *T*'s during the same period. For four infants, *C*, *D*, *K*, and *Mi*, the number of micturitions exceeds the number of series of *T*'s, whereas for the other five infants, the reverse is true.

The number of series of *T*'s per day, as well as the total number of *T*'s varied considerably for each infant. For example, *B* had no

T's on the second day but experienced eight series of *T*'s and a total of 12 *T*'s on the ninth day, whereas *W* had eight series of *T*'s for a total of 11 *T*'s on the second day and 12 series of *T*'s for a total of 67 *T*'s (mostly transient) on the eighth day *D* who had the least number of *T*'s went two days and two afternoons without *T* *C* had no *T*'s on four afternoons; while *M* and *Mi* had no *T*'s on one afternoon

That there was little correspondence between age and frequency of voiding is shown in Table 5 The age range, however, was narrow 3 to 20 weeks The three youngest infants, *A*, *W*, and *B*, voided 55, 64, and 46 times respectively, whereas *C* and *D*, two of the older infants, voided 53 and 45 times respectively. On the other hand, *K*, the oldest infant, voided 86 times, whereas *E*, one of the younger infants, voided 88 times during the 10-day period of observation.

The greatest inconsistencies in frequency of micturition per day were displayed by *E* who urinated only four times on one day and 13 times on another, and by *K* who voided six times on one day and 15 times on another. On the other hand, *A*'s range was only three to seven voidings per day

Individual differences in the frequency with which *T* was present at micturition may have been largely due to differences in age For the four youngest infants, *A*, *W*, *B*, and *E*, the number of micturitions with *T* was from two to four times as great as the number of micturitions without *T* For the four oldest infants, micturitions without *T* outnumbered micturitions with *T* by more than two to one in two instances (*C* and *D*) and were only slightly less in number to micturitions with *T* in the other two instances (*K* and *Mi*).

Individual differences in the tendency for *T* and in the desire to micturate under varying conditions of bladder content are shown in Table 11 *D*'s control of the act of micturition was exceptionally good. His median time between micturitions was 100 minutes and he occasionally went three or four hours without voiding The frequent absence of *T* at voiding (see Table 5) and the fact that *D* experienced but 31 series of *T*'s over the 10-day period, indicate a low susceptibility to *T* even in the presence of a full bladder. In this respect infant *E* stands in direct contrast to *D* *E*'s median time between successive micturitions was only 35 minutes. On occasions he voided four or five times within a half-hour *E* had a total

TABLE 11

COMPARISON OF TIME BETWEEN SUCCESSIVE MICTURITIONS, TIME ELAPSING BETWEEN MICTURITION AND *T*, AND TIME BETWEEN SUCCESSIVE SERIES OF *T*'s[1]

Infant	Time between micturitions Median Min	Time between micturitions Rank order	Time elapsing between micturition and *T* Median Min	Time elapsing between micturition and *T* Rank order	Time between series of *T*'s Median Min	Time between series of *T*'s Rank order
A	65	5.5	50	6	25	1
B	75	8	40	3	60	7.5
C	70	7	70	8	65	9
D	100	9	75	9	60	7.5
E	35	1	35	1.5	40	3.5
K	45	2	35	1.5	40	3.5
Mf	65	5.5	45	4.5	45	5.5
Mi	60	4	65	7	45	5.5
W	50	3	45	4.5	35	2

[1] Compiled from Tables 3, 6, 10.

of 88 micturitions, 81 per cent of which were attended by *T*. For the remaining seven infants, the frequency of *T* and micturition under varying degrees of bladder pressure ranged between the two extremes represented by infants *D* and *E*.

Soiling during *T* and soiling in the absence of *T* occurred with equal frequency for the infants as a whole. Five infants soiled oftener during *T* than without *T*, whereas for the other four infants, the conditions were reversed. The records of *B* and *W* in this respect are in sharp contrast. The former seldom evidenced *T* with soiling, whereas *W* seldom accomplished the act without *T*. *W* appeared to experience difficulty with soiling even though he was not constipated. The act was always accompanied by flexing the legs sharply, twisting, and grunting. When voiding and soiling occurred together, *T* was always present for *W*. With the exception of infant *W*, the number of concurrent voidings and soilings without *T* equal the number with *T*.

Voiding and soiling were frequently complicated by the presence of *T*. To what extent *T* interferes with the performance of either act is a matter of conjecture. Observations indicate that the presence of the phenomenon on many occasions interrupts voiding and at other times delays it. The crying which in some instances occurred after a long period of *T* may have been due to continued turgidity of the congested organ, or it may have been due to the inability to void the distended bladder at this time. At any rate, when voiding finally occurred under these circumstances, the flow was copious and the force of the stream was sufficient to carry it several feet beyond the head of the infant *B* and *M* were frequently in distress when *T* of long duration preceded micturition On the other hand, there were many instances in which infants who had not micturated for a long time repeatedly voided small amounts of urine in the presence of *T*. Although the situation in these cases was not as distressing as in the instances cited above, the interruptions of the flow of urine was at best annoying For example, E who on one occasion was asleep urinated seven times in 40 minutes during a protracted period of *T* and on each voiding awakened and either fretted or cried Three of the voidings occurred within 10 minutes Hence, although several voidings were necessary to empty the bladder, the relief which came from each of the series of uncompleted acts was sufficient to prevent distress.

There were other factors which tended to complicate the behavior of infants after voiding and soiling Sometimes soiling without *T* was followed immediately by *T* which disappeared when voiding subsequently occurred Occasionally these acts occurred in reverse manner. Then again, both voiding and soiling, separated by an interval sometimes as long as 10 minutes, occurred before *D* set in. At other times voiding without *T* was followed by voiding with *T* after a lapse of only 15 minutes, or less When voiding occurred during sleep in the presence of *T*, the infant either startled and moved restlessly, or opened his eyes momentarily, or roused to complete wakefulness When two or more voidings or soilings occurred in close succession, restlessness, fretting, or crying were frequent

With the exception of *E*, the more restless infants as a rule did not urinate oftener than the quiet ones. It is probable that *A*, *B*, *M*, *W*, and *D* might have been less restless if they had urinated more frequently

The quiet infants, *C*, *K*, and *Mi*, slept better than the others *C* and *Mi* usually experienced *T*'s of relatively short duration and the phenomenon generally occurred just before voiding or soiling and usually was followed immediately by these acts. *K* was frequently disturbed by sudden *T*'s but they disappeared as quickly as they came. It was noted that infants usually became somewhat restless with the onset of *T*. As turgescence increased, restlessness also increased and frequently, in the sleeping infant, reached a stage which repeatedly startled him awake. A thorough evacuation of bladder or colon undoubtedly has a quieting effect on infants. *C*, *K*, and *Mi* frequently babbled, smiled, or uttered soft squeals on these occasions

D. Discussion

1. *Bladder Pressure and T*

It was suggested in an earlier paper (13) that the reflex acts of micturition and *T* were probably closely related, and that the pressure effects of a distended bladder which led to reflex contractions of the muscle of this organ in voiding were also effective in producing *T*. Similarly it was suggested that *T* which occurred during the act of defecation in which the abdominal and pelvic muscles contracted to crowd the internal organs of the viscera might also be explained by the same principle It was also suggested that in the excitement of a hampering situation the marked contractions of the abdominal muscles against a full or partially filled bladder might be as effective as a distended bladder alone in producing *T*. The fact that voiding or soiling frequently occurred during or soon after the hampering situation indicated that on many of these occasions either the bladder or pelvic colon was full or partially filled

Authorities in general (7, 11, 16, 17, 18, 24) agree that erection and strong contractions of the bladder can both be produced by stimulation of the pelvic nerves Gruber says (11, p 554), "The pelvic nerves are capable of causing contraction of the bladder, relaxation of the sphincter, and erection of the penis in the male." He adds that if erection occurs, voiding will quickly subdue it. Goltz (10, p 464) asserts that stimulation of the bladder elicits erection. In addition, the experiment by Goltz (10) in which pressure directed on the wall of the rectum against the bladder elicited erection in dogs after section of the spinal cord, indicates the probability of erection in the presence of fecal pressure. In fact, Goltz states that spontaneous erection apparently occurs in the presence of a full bladder or a full colon

Henderson and Roepke (14) suggest that "skeletal, ischio-cavernosus, muscular contractions may play some minor part in erection." Furthermore, whereas it is generally conceded (11, p. 554, 15, 16, p 886, 17, pp. 283-285, 23, p 962) that reflex voiding is caused by reflex contractions of the bladder muscle due to pressure within this organ, bladder pressure and the desire to urinate do not depend entirely on the quantity of urine present Howell (16, p 886) states that the condition of tone of the bladder muscle determines in part the pressure within this organ and that, therefore, there may be a strong desire to urinate when the contents of the bladder are small in volume. Other evidence (17, p 284, 23, p. 962) indicates that contraction of the abdominal muscle itself increases the pressure in the bladder and thus causes voiding or the desire to void even when there is but a small amount of urine in this organ

The evidence, viz, that stimulaion of the pelvic nerves or bladder can bring about both reflex bladder contraction and erection, indicates that these two activities are more or less functionally related. The fact that bladder pressure can produce erection and that bladder pressure itself does not depend upon the quantity of urine present, may account for the frequent occurrence of T not only before copious voiding but also in instances wherein there is little or no voiding In addition, inasmuch as marked emotional disturbances frequently bring about the urge to urinate and may even result in involuntary voiding (17, p. 288, 5, p. 31), it is quite possible that this emotional excitement may also be effective in producing T, either by increased bladder pressure or by nervous discharge via the pelvic fibres

If the above explanations of the occasion for T are tenable, present conditions which contributed to the onset of the phenomenon are as follows. (*a*) Pressure within the bladder, as indicated by subsequent micturition, 300 instances, (*b*) pressure within pelvic colon, as indicated by subsequent defecation, 42 instances, (*c*) pressure within both bladder and pelvic colon, as indicated by subsequent micturition and defecation, 34 instances, (*d*) hampering of the sucking activity, complicated in many cases by the presence of a full or partially filled bladder, 27 instances, (*e*) conditions not definitely known, 233 instances

If the 233 instances in which T occurred under conditions not directly associated with either micturition, defecation, or hampering, are examined more closely, it is found that 68 of them occurred after an interval of more than 100 minutes had elapsed since a previous voiding Inasmuch as the median time between voidings for the nine infants varied from only 35 minutes to 100 minutes (the median of all the medians is 65 minutes), the assumption that a time interval greater than 100 minutes represents a long period between voidings and that therefore the 68 *T*'s referred to above occurred under conditions of a well filled bladder appears justifiable. If the assumption that 65 minutes constitutes a sufficiently long period for the accumulation of urine adequate for inducing *T*, the number of unaccountable *T*'s is reduced to 140. Furthermore, in 29 instances a series of *T*'s apparently unrelated to micturition occurred within 10 minutes after either micturition or defecation. These post-micturition *T*'s, listed as non-specific, may well have been due to a disposition for further voiding or evacuation when either of these acts was not fully consummated, or to some internal organic adjustment following micturition or defecation Many of these 29 *T*'s were attended by restlessness, fretting, grunting, stretching, stiffly executed leg flexion, holding the breath, and other evidences of muscular straining of the sort which precedes micturition or defecation. In this connection it is also of interest to note that 25 micturitions, 11 defecations, and two concurrent micturitions and defecations, all of which were attended by *T*, occurred within 10 minutes after a previous voiding. Finally, if a series of *T*'s during which neither voiding nor soiling occurred, are viewed as part of a subsequent series of *T*'s during which one or the other of these acts did take place, even though the two series were separated by a time interval greater than 10 minutes (the time limit arbitrarily set) bladder pressure may be regarded as the effective stimulus for *T* in the remainder of the 233 instances in which the conditions which produced *T* were listed as non-specific.

It may also be mentioned that the condition of tone of the bladder muscle, i.e., capacity to retain urine, undoubtedly varied considerably for individual infants. *D* and *B*, for example, voided very infrequently, often going three hours without urinating whereas *E* and *K* voided small amounts of urine at frequent intervals and also made a great many unsuccessful attempts to urinate and defecate. It has already been noted that *T* was a common occurrence with the latter infants. In passing, attention is called to the fact that the three infants who had the smallest number of micturitions also had the smallest number of series of *T*'s (see Tables 1 and 5) and that three of the four infants (*E*, *K*, and *W*) who urinated most frequently were among the four who had the most series of *T*'s. This connection between micturition and T is also shown, although not too convincingly, by the correspondence between the rank orders for (*a*) time between successive micturitions, (*b*) time elapsing between micturition and subsequent T's, and (*c*) time between successive series of T's (see Table 11).

2. *Other Evidences of Tension during T*

Observations and results indicate that in general the organism during T is in a state of generalized tension, involving varying degrees of distention of either bladder or colon, or both, and the resultant increase in muscular straining. The greater the turgidity of the penis, the greater the tension and the greater the emotional excitement The situation may be described as unpleasant, annoying, distressing, or even painful During D the organism is undergoing a reduction of this state of tension

Peculiarities of behavior more or less common to the infants, some of which have not already been mentioned in the text, give further evidence of this state of the organism during T (*a*) The straining activity involved in defecation sometimes continues after the act is completed and occasionally results in T; (*b*) T usually increases with stretching, either with the legs in full extension or drawn up over the abdomen; (*c*) infants frequently raise their legs stiffly and rub their heels against the scrotum or penis during T; (*d*) maximum turgidity is accompanied by penial vibration and stiffening of the skeletal musculature.

Crying often occurred in the absence of T and even on days entirely free of T. Infants cried during the pre-feeding period They cried when they were sleepy and could not attain sleep They awakened from sleep for no apparent cause and cried. However, the crying which began during T and was attributed to the presence of this phenomenon consisted of sharp screams or single staccato-like squeals. Marked physical activity accompanied these emotional outbursts In this connection it has previously been noted that T appeared to hinder and at times actually to prevent micturition. If this is actually the case, as more urine accumulates the bladder becomes unduly distended and causes distress and probably physical pain. If T occurs as a by-product of pressure stimulations of the bladder, a distended bladder might conceivably cause greater turgidity and this in turn (vicious circle) increase the tendency to prevent micturition Relief is finally attained when the pressure of the urine has increased beyond the limit of turgescence to prevent voiding When voiding occurred under these conditions the urine was directed upon the infant's head, on the wall behind the infant, or on the crib at his left

Thumb sucking also occurred in the absence as well as in the presence of *T* *During quiescence this activity was usually accomplished with a relatively small expenditure of effort.* Thumb sucking during *T* was frequently carried on in an excited, forcible, and even a frantic manner When *T* on these occasions was followed by *D*, the commotion attending sucking gradually ceased and was succeeded by quiet sucking

Quiescence during and after *D* was quite general. The number of times infants were quiet during *D* is not fully represented by the instances labeled as quiescence because this category includes only those cases in which no other form of activity occurred. To the 138 instances of quiescence should be added most of the cases in which thumb sucking, milk sucking, and either or both micturition and defecation occurred In fact, the situation during *D* was one in which the infant appeared to experience comfort and relief. It could not be determined whether *D* and quiescence were merely coincidental, whether *D* occurred as a result of quiescence, i e., general passivity of the body neuro-musculature, or whether *D* induced quiescence

If, on the other hand, as the records show, infants usually manifest restlessness or distress during *T*, what explanation can be offered to account for the 91 instances of quiescence in the presence of this phenomenon? Two explanations have been suggested: (*a*) The turgidity of the penis during *T* did not attain the state at which distress is evidenced, (*b*) the internal stimulation which was effective in producing *T* was not of sufficient intensity to cause distress For example, if the assumption that pressure stimulations of the bladder may evoke *T* is valid, a partailly filled bladder may conceivably produce *T* without necessarily causing annoyance.

Irregularities in the occurrence of *T* at times cast doubt on its connection with micturition or defecation. On 22 occasions when *T* apparently forecast micturition, voiding did not occur until *T* disappeared. On four occasions defecation also occurred under these circumstances. In 13 *instances voiding during T was followed by* voiding after the disappearance of *T*. In two instances soiling during *T* was followed by voiding after *D*, and in six instances these conditions were reversed. In all the above cases micturition and defecation were recorded as associated with *T*, because they occurred within five minutes following *D* On other occasions when the time interval was greater than five minutes, the possible relationship was ignored.

3 *Possible Effects of Posture and Clothing on T*

Although the supine position apparently inflicted no undue hardship on the infants, according to the attendants, the physiological effects of remaining constantly in this position may in some way have affected the behavior of the infants It would be interesting to know if timely changes to the prone or lateral positions might have produced different results than those obtained Mention was made of the fact that two of the infants (*C* and *Mr*) usually lay on their sides during sleep. Now it so happens that with the exception of *D*, fewer *T*'s were experienced by either of these two infants than by any one of the others over the 10-day period (Table 1), and also that they were among the four infants who experienced the smallest number of *T*'s during sleep. It was impossible to determine whether the relative infrequency of *T* in these cases was due to accident, to native constitution, or to physiological effects of posture.

There is also the question as to whether the same results would have been obtained if the infants had been clothed. No definite answer can be made to this question, and unfortunately, the presence of clothing would have prevented the observation of much of the behavior recorded in this study It is relevant to state that, whereas in a situation such as this, clothing may possibly have been beneficial to the comfort of the infants, it may also have produced detrimental effects on the infant by the restriction of movements in general and by obstruction of the course of movement of the penis during *T*

4 *Deviations from the T-M-D Series*

The frequent occurrence of the *T-M-D* (tumescence-micturition-detumescence) series was perhaps the single outstanding feature of the study This order of events occasionally occurred quite regularly throughout the day for some infants In fact, correct prediction by attendants that voiding was about to take place during T were numerous. In most instances, however, the regular occurrence of these series was interrupted by one or more T-D series. At times the order was complicated by sucking, fretting, crying, or awakening. At other times the serial order changed unexpectedly to T-D-M.

5. *Frequency of Micturition and Defecation*

Micturition in infancy is a function of a lower reflex arc and probably operates through autonomic extra-spinal centers (4, p. 326). It is likely that in the early months of human life, voidings or attempts to void occur with the first stimulus of the desire to urinate According to Schanjawski (4, 8, 12) the average frequency of urination in 24 hours by normal children of 1 to 3 months of age is 14; and that of chidren 3 to 6 months of age is 20. If the number of micturitions during an 8½-hour period of observation is a true indication of the frequency of voiding, the average number of voidings per a 24-hour day for the nine infants of this study is 18 6. Great individual differences in frequency of voiding are shown by the fact that D averaged only 13.3 micturitions over a 24-hour period, whereas E averaged 26.2.

Infants normally have four or five stools a day during the first week (12, p. 15) This number is usually reduced to 2 or 3 by the end of the second week. However, according to Marriott (19, p 78), thriving infants may have but one stool a day or they may have seven or eight. "The number of stools depends upon the total amount and character of the food and the presence or absence of infection in the intestinal tract or elsewhere, and the individual tonicity of the gastro-intestinal musculature." Schick and Rosenson (21, p. 235) state that the frequency of defecation varies with the individual infant and ranges from one to three stools in 24 hours or longer. Sherbon (22, p. 198), on the other hand, says that the child tends to have a bowel movement after each feeding. According to the present study which was conducted in daylight, the average number of defecations per 24 hours for the group of nine infants is 4.7. The average frequency for the individual infants varies from three for C and E to 8 3 for A, the youngest baby.

E. CONCLUSIONS

1. This study shows the frequency of occurrence of penial tumes-

cence (T), micturition, and defecation for nine male infants over a 10-day period of observation.

2. T was a common occurrence for all infants. The phenomenon occurred singly and in series, and its duration varied from less than 0 5 minutes to 66 minutes Individual differences were marked For some infants T was usually of long duration, for others, the phenomenon was usually transient, whereas some infants experience both long and short T's

3. The total number of series of T's was 636, of which 301 were isolated T's The median number of series per day for the individual infants varied from 3 to 11.

4 T occurred more frequently during each of the first three hours after feeding than during the fourth hour. It occurred during sleep as well as during wakefulness and frequently awakened the infant.

5. Time intervals between series of T's varied greatly for the different individuals. The shortest time interval was 10 minutes; the longest, 320 minutes.

6. The behavior during T was characterized by restlessness, stretching, rigid leg flexion, crying, fretting, thumb sucking, and stirring Some infants were greatly disturbed, others only mildly affected, by the presence of T.

7. Voiding occurred with greater frequency during each of the first three hours after the feeding period than during the fourth hour The greatest number of micturitions occurred during the first hour after feeding

8. Intervals between successive voidings, as shown by the medians for the individual infants, varied from 35 to 100 minutes The maximum time intervals between micturitions varied from 170 to 285 minutes, and the minimum time intervals from 5 to 20 minutes

9. Defecation occurred most frequently during, or within half-an-hour after, feeding. The number of defecations during the first hour after feeding far outnumbered those at any other hour.

10. The median number of micturitions per 8½-hour observation day for the individual infants varied from five to nine The median number of defecations for the same period varied from one to three.

11. Four hundred and thirty-three micturitions and 121 defecations occurred during wakefulness; 81 micturitions and four defeca-

tions occurred during sleep. Infants were awakened by the excretory acts on 50 occasions of voiding and on 17 occasions of soiling.

12. Infants were usually quiet during and after micturition and defecation.

13. Altogether there were 507 micturitions, 85 defecations, and 57 concurrent micturitions and defecations during the 10 days. Sixty-one per cent of the micturitions, 49 per cent of the defecations, and 60 per cent of the concurrent micturitions and defecations were attended by varying degrees of turgidity of the penis

14. *T* occurred immediately after voiding on 71 occasions and after soiling on 17 occasions.

15. That pressure stimulation of the bladder is the most probable cause of *T*, insofar as this study is concerned, is supported by the following evidence. (*a*) The frequent occurrence of *D* during or immediately after voiding, (*b*) the prevalence of the *T-M-D* series; (*c*) the close correspondence between the distribution of voidings and *T*'s throughout the morning and afternoon periods; (*d*) the frequent occurrence of *T* after partial voiding or on attempts to continue the act; (*e*) in general, infants who had long intervals between *T*'s also had correspondingly long intervals between voidings, and between voidings and subsequent *T*'s; while infants who had short intervals between *T*'s had correspondingly short intervals between voidings, and between voidings and subsequent *T*'s, (*f*) physiological experiments on dogs have demonstrated that pressure stimulation of the bladder is effective in producing *T*.

16 Fecal pressure in the colon and rectum directed against the bladder probably accounts for the frequent voidings and also for the presence of *T* at defecation

17. The indications are that *T* tends to prevent voiding and that the greater the turgidity of the penis, the greater the interference with voidings.

18 Post-micturition *T* was probably due to perseverative bladder tonus following complete or incomplete voiding.

19. The 27 *T*'s which occurred during the excitement of waiting for the bottle were probably elicited by pressure stimulation of the bladder as a result of contractions of the abdominal muscles, or by nervous discharges via the pelvic autonomic fibers.

20. *D* usually occurred during quiescence, frequently at or after voiding or soiling

21 The four principal conditions which contributed to crying were inability to sleep, *T*, hunger, and restlessness.

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STUDIES IN HUNGER I. THE EFFECTS OF INSULIN UPON THE RAT'S RATE OF EATING*

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A INTRODUCTION

The first important contributions of experimental science to the psychology of hunger were made in the researches of Cannon (1906, 3; 1911, 4), Cannon and Washburn (1912, 5), and Carlson (1912, 6) These experiments as well as many that followed led to the conclusion that the "sensation" of hunger arises when the walls of the empty stomach contract. This local theory of hunger seems to have survived many objections, and research in more recent years has been applied to the study of the factors which control gastric motility. No single determiner of motility has been revealed in these studies. The gastric contractions may be present in the absence of nervous innervation (Hofmeister and Schultz, 10). But apparently the regulation of motility is normally vested in the *antagonism of sympathetic and parasympathetic nerve supply* (Cannon, 3; Mulinos, 14; Quigley and Templeton, 17, 18; Wilder and Schultz, 26). The many factors which may alter gastric motility, e g , emotion, smoking, ingestion of food, injection of insulin or atropine, produce their effects by the facilitation or inhibition of one or the other of these systems of innervation (Borchers, 1; M'Crea, M'Swiney, and Stopford, 12; Mulinos, 14; Quigley and Templeton, 17, 18).

If hunger as a "sensation" is derived from contractions of gastric musculature and if the control of these contractions is normally regulated by nervous influences, then those factors which in turn affect nervous control become significant in the study

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of the physiological basis of hunger. Hunger is related biologically to the organism's need for nutrition It would seem reasonable, then, to expect that in the last analysis the control of hunger would be due to humoral changes. In line with this expectation, Bulatao and Carlson (2) found that the injection of insulin produced powerful gastric contractions Since that time insulin has remained a faithful agent for the experimental production of gastric hypermotility (14, 19, 21, 24)

Of course the most prominent physiological effect of insulin injection is the reduction of blood sugar level. Bulatao and Carlson (2) and La Barre and Destrée (11) discovered that insulin hypermotility of the gastro-intestinal tract does not appear until the blood sugar level has reached a value significantly below normal The expectation which follows upon this fact is that normal variations in blood sugar level may be the critical humoral factor in the control of hunger. To the contrary, many researches have found no such relationship to exist (14, 16, 20).

To summarize the facts concerning the relationship of insulin and blood sugar level to gastric motility, the injection of insulin results in hypermotility when hypoglycemia has reached a significant level, but normal variations in blood sugar level and experimental hyperglycemia seem to bear no relation to gastric motility. Obviously, the critical humoral agent, should there be one, has not been discovered in these researches Another factor in addition to insulin concentration and blood sugar level, but concerned with their relationship, may well prove to be critical.

The fact remains that some reaction related to insulin hypoglycemia does heighten gastric motility. This relationship, in view of the local theory of hunger, raises the problem of the relationship of insulin injection to hunger. It is this problem whose investigation is reported in this paper With regard to methodology, the best measure of the effect of insulin upon hunger would appear to be the comparison of normal food-intake with the amount ingested after the injection of insulin. Three studies of this type by other workers already appear in the literature.

Freyburg (8) studied the effect of insulin injection upon appetite or hunger as compared with weight changes and the average daily caloric intake. Nine human subjects who were undernourished and complained of poor appetite were studied. The patients were given control doses of saline when insulin was not injected. Seven of the nine subjects had no increase in appetite, food consumption, or weight Five actually lost weight The author concludes that the "investigation fails to support the prevalent opinion that insulin is a valuable aid in the treatment of undernutrition." Maclegan (13) investigated the relation between the amount of food eaten and the injection of insulin Eight rabbits were used The administration of 10 units was followed by an increase of 10 per cent over the normal food consumption The injection of five units of insulin along with 10 cc of 25 per cent glucose solution resulted in a decrease of 11 per cent. Although clinical workers frequently use insulin to increase the appetite, these two studies seem to be the only thorough experiments Wentink (25), on the basis of a limited number of eating records of rats, concludes that insulin may increase or decrease the eating rate and that "there is a very delicate balance between the factors producing an increase and those producing a decrease" (p 157).

The study reported here involves essentially the same method as that of the three studies just reviewed The amount of food consumed by rats was measured in relation to the injection of insulin

B. Apparatus and Animals

Skinner (22, 23) has devised an apparatus particularly suitable for quantitative study of the rat's rate and amount of eating A modification of this apparatus (9) was used in the present experiment The apparatus consisted of electrically operated feeding and recording mechanisms A small lever projected into a feeding compartment Depression of this lever by the rat closed a switch which operated a feeding mechanism from which a constant amount of food (one-tenth gram) was delivered down a chute into a tray in the compartment Each depression of the lever which released food was recorded by an ink writer on a slowly moving drum The complete details of the device are presented elsewhere (Hanford and Morgan, 9)

One important change from the description previously published should be noted. In the course of preliminary experimentation it was found that rats sometimes pushed the lever when food was already in the tray and they sometimes gave several responses after they had discontinued eating Since lever-pressing was the response recorded on the kymograph, under these circumstances the record which was obtained was an inaccurate record of the actual eating rate. To eliminate this difficulty, the tray itself was placed on a delicate lever connected with a switch The other end of the lever could make contact with a mercury cup switch. The circuit was so wired that this switch had to be closed in order for lever depression to activate the feeding and recording mechanisms. The sensitivity of balance of the food-pan lever was two-tenths to three-tenths grams so that two or three "shots" of food were sufficient to depress the lever to which the food-pan was attached. The result was to break the mercury contact and further depression of the principal lever by the rat could not operate the feeding mechanism until the food in the tray had been consumed. This device made possible the restriction of the *recorded* lever-pressing activity of the rat to conform quite precisely to the actual eating rate.

Eight female rats of about nine months of age at the beginning of the experiment were used. Their weights at this time were 160 to 230 grams. A standard mixed diet was used throughout the entire experiment It was a granular mixture of the following proportions by weight: yellow corn meal, 50 per cent; Purina dog chow, 30 per cent; and pure granular gelatin, 20 per cent.

A large but safe amount of insulin was determined by administering various dosages to several rats before beginning the experiment. Four-tenths cc. of 40*U* Iletin insulin was usually fatal for rats weighing about 200 grams. Three-tenths cc. usually produced marked shock but two-tenths cc. did not if the animal was allowed to eat within an hour after the injection. Accordingly, two-tenths cc. or eight units of Iletin insulin was the dosage used throughout the experiments.

C. PROCEDURE

The eight rats used in the study were placed on a feeding schedule for several days Following this they were trained to push the lever to obtain food in the feeding box. They were then used daily in this box for about four months on other problems before beginning the present experiment. In the present study, they were placed in the box for feeding at the same hour every day. On one day, insulin was injected and on the next, saline. Thus, every other day they were given insulin and the alternate days served for control.

The study involved four series which differed only in the amount of time that was allowed to elapse between the time of injection of the insulin or saline and the time they were placed in the box In any case they were placed in the box at the same time every day and allowed to feed for one hour In Experiment I, the animals were placed in the box immediately after injection, that is, the interval was 0 minutes In Experiment II, they were permitted to start eating 15 minutes after injection In Experiment III, the interval was 30 minutes and in Experiment IV, 60 minutes. A rest period of a week or more elapsed between each experiment.

The four experiments were performed in the following order· I, IV, III, II Eight animals were used for I, IV, and III but sickness developed in one animal during Experiment III, its rate of eating being so variable that its entire record for this experiment was discarded. Evidently the effect was due to the continued doses of insulin for later a similar illness and loss of weight appeared in two other animals. Therefore records were available for only five animals in Experiment II.

D. RESULTS

In all four experiments several records were obtained for each animal. It was desirable to tabulate these records in a distribution so that customary statistical treatment could be given the data. In order to accomplish this end, a sort of nomograph was made which could be laid over each kymographic record and the number of responses made at each 10-minute interval during the hour's feeding could be determined. A prominent feature of the data grouped in such distributions was the wide dispersion of values. Variability in such an experimental arrangement may be due to many undetermined factors, but one source of variation which was readily identified consisted of individual differences among rats especially with regard to the amount eaten Since the study was not concerned with these individual variations but with general group trends, a legitimate method of ruling out this variability was employed. For each experiment, the average number of total responses for the saline days was determined for each rat. For each rat then, each value of saline and corresponding insulin records was converted into percentages of the average control responses for the rat. In this way the variability of the records due to individual differences was eliminated but in no way was the relationship of an animal's control scores to its insulin scores modified. Percentage-scores secured in this way were used in all of the computations reported here.

From these percentage-scores the mean control and insulin curves were computed. When the four control curves, one for each experiment, were secured and compared, there appeared to be no significant differences between them. Therefore the four control distributions were classed together to form one control distribution of 187 curves. The number of insulin records obtained in the four experiments were respectively 61, 44, 36, and 39. The reliabilities of the differences between insulin groups and control groups of curves were computed from the ratio of their differences to the standard errors of the differences. The formula used to secure the standard error of the difference was:

$$\sigma_{diff} = \sqrt{\sigma_{M_1}^2 + \sigma_{M_2}^2}$$

The two distributions might have been correlated since the same animals were used for both, but it was not possible to include correlation coefficients in the formula because of the variable number of records secured for each animal.

TABLE 1

MEANS OF CONTROL AND INSULIN CURVES, THEIR STANDARD DEVIATIONS, AND RELIABILITIES OF THEIR DIFFERENCES

Minutes		10	20	30	40	50	60
Control	Mean	23.08	43.71	62.68	79.10	91.13	99.79
($N = 187$)	SD	8.54	13.73	18.00	19.84	21.39	22.61
Insulin	Mean	25.34*	45.54*	62.37	78.43	89.75	98.60
($N = 61$)	SD	6.72	9.87	12.03	13.22	15.00	17.78
0 minutes	D/σ_{diff}	2.09	1.13	.15	.30	.56	.42
Insulin	Mean	22.04	42.00	63.68*	80.41*	96.77*	111.55*
($N = 44$)	SD	7.45	13.06	17.35	18.13	19.29	22.72
15 minutes	D/σ_{diff}	80	77	34	42	2.13	3.09
Insulin	Mean	19.00	39.22	55.89	66.17	76.72	93.94
($N = 36$)	SD	9.67	15.01	22.13	27.13	29.45	35.07
30 minutes	D/σ_{diff}	2.35	1.66	1.73	2.72	2.79	96
Insulin	Mean	17.74	31.87	46.55	57.83	65.01	71.09
($N = 39$)	SD	7.83	11.96	15.22	13.16	16.79	19.15
60 minutes	D/σ_{diff}	3.78	5.48	5.82	8.24	8.40	8.24

*Means which are higher than corresponding control means.

The results of the study are summarized in the accompanying tables and graph. In Table 1, it is readily seen that there are reliable differences in two directions In one experiment, insulin injection produces an increase in feeding rate In another, very marked depression occurs. In still a third, there is a marked tendency toward depression but the ratio of the difference to its standard error in no case reaches three The different results of the four experiments are plainly associated with the interval between injection and beginning of the feeding If the feeding begins immediately following the injection (Experiment I) no significant differences in the amount eaten appear at any time throughout the hour If the interval is 15 minutes (Experiment II), the eating rate proceeds normally to the point where the normal curve begins to decelerate more rapidly At this time, 40 minutes after beginning to eat, the insulin

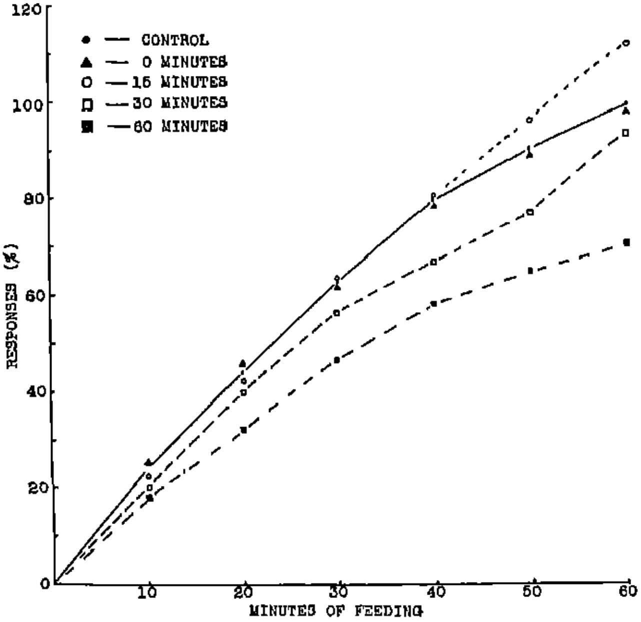

FIGURE 1

AVERAGE CURVES OF FEEDING RESPONSES WITH DIFFERENT INTERVALS OF TIME BETWEEN INJECTION OF INSULIN AND THE BEGINNING OF FEEDING curves fail to drop off but continue in a straight line. In consequence, about 10 per cent more food than normally is eaten when the hour's feeding period begins 15 minutes after the injection of insulin. When the interval is 30 minutes (Experiment III), there is a definite tendency for depression of the eating rate for the first 50 minutes. In the last 10 minutes, the rate increases over the normal value; the reason for this is not clear. In Experiment IV where the interval is 60 minutes, depression is marked throughout the entire period.

It should be stated that these results are not due to a few cases or skewed distributions. When the medians of the distributions are examined, the same essential differences appear. These medians are given in Table 2. Other methods of statistical analysis, including the examination of average curves of individual rats, still further verify the validity and reliability of the results as they have been described here.

TABLE 2

MEDIANS OF CONTROL AND INSULIN CURVES

Minutes	10	20	30	40	50	60
Control	22.1	45.4	62.4	80.7	91.5	100.3
Insulin 0 minutes	25.1*	45.3	62.0	77.8	90.5	102.2*
Insulin 15 minutes	23.2	43.8	62.8*	78.7	95.9*	110.5*
Insulin 30 minutes	21.0	44.4	59.4	71.7	75.4	91.4
Insulin 60 minutes	16.2	32.5	50.0	61.1	68.3	72.2

*Medians which are higher than corresponding control medians

At least one conclusion can be clearly drawn from the data. The time interval between feeding and the injection of insulin is a determinant of the effect of the insulin upon the feeding curve. With a 15-minute interval, the height of the curve is extended and with longer intervals a portion or all of the curve may show depression of the feeding rate.

E. DISCUSSION

The results of this study support the work of Maclegan (13) and the clinical practice of injecting insulin to aid appetite (7). In addition, the results support Wentink's (25) conclusion that in the use of insulin a balance exists between factors leading to facilitation of hunger and those leading to depression. In the light of the results, furthermore, there seems to be little difficulty in accounting for Freyburg's (8) negative results.

The present study shows that depression of feeding rate and facilitation of feeding occur at different intervals after the injection of insulin. Many previous studies concerning the motility of the stomach show similar effects. They have found that gastric motility is first depressed and afterward there occurs a period of gastric hypermotility (Mulinos, 14, Quigley and Templeton, 18; and Regan, 19). Now in the study reported here the period of heightened feeding activity occurs when insulin is injected 15 minutes (Experiment II) before feeding and a lowered feeding rate follows 30- (Experiment III) or 60- (Experiment IV) minute intervals. It should be observed however that in Experiment II the period of heightened activity did not occur until 55 to 75 minutes after injection. In Experiment III, acceleration appeared between 80 and 90 minutes after injection. Depression occurred in Experiment III between 30 and 80 minutes and in Experiment IV between 60 and 120 minutes. Clearly, in different experiments the depression and facilitation periods *are not* mutually exclusive.

In order to account for this discrepancy it seems necessary to postulate that eating itself must in some way modify the effect of the insulin upon the feeding activity. Little more than this supposition can be safely introduced. Perhaps further research will provide an acceptable interpretation for these results. Since depression is first seen at 30 minutes after injection and facilitation first appears 55 minutes afterward, it *might* be concluded that these results support the studies cited above (14, 18, 19) concerning gastric motility.

The limited agreement of this study with those experiments on gastric motility in relation to insulin might lead to the inference that the local theory of hunger (Cannon, 3, 4, 5) is supported. Since the evidence is not direct in its bearing upon this problem, it would seem more proper to reserve a conclusion. Experiments now being completed and involving a study of the eating rates of vagotomized and gastrectomized rats subjected to insulin injection may throw more light on this problem.

F. Summary

1. Eight rats were fed daily for one hour in a Skinner-type feeding apparatus and their feeding responses were kymographically recorded.

2. The rats were subjected to insulin and saline (control) injections on alternate days to study the effect of insulin upon the eating rate.

3. Four experiments with four different time intervals between injection and the beginning of feeding were conducted. The intervals employed in these experiments were respectively 0, 15, 30, and 60 minutes.

4. In the first experiment involving insulin injection immediately before feeding, no significant effects of insulin were noted. When the interval was 15 minutes, the total amount of food consumed was about 10 per cent above normal. This increase was accounted for by the failure of the curves to fall off, as it does normally, during the last 20 minutes of the hour.

5. The most significant effect following the use of longer intervals (30 and 60 minutes) was a marked depression of the eating rate and of the total amount eaten.

6. The study indicates that insulin does affect the hunger drive as measured by the rate and number of feeding responses. The effect may be a depression or a facilitation depending upon the time relations between injection and feeding.

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THE SEX HORMONES AND EMOTIONAL BEHAVIOR
I. THE EFFECT OF SEXUAL RECEPTIVITY UPON TIMIDITY IN THE FEMALE RAT*

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The writer (1, 2) has reported significant negative correlations between measures of sexual drive and timidity in the male rat That is, male rats which were most active in the tests of sexual behavior tended to be least timid in tests of emotionality. If such a relation also holds for the female rat, it might then be expected that sexually receptive females should be less timid than non-receptive females. The present study demonstrates the validity of the above inference

A PROCEDURE

The general procedure was to compare the emotional performance of a group of females when they were in heat (as determined by indicator males) with the performance of a group of females which were not in heat. The test was repeated two days later when both groups were non-receptive In selecting the groups, the females were examined for external signs of oestrum. A female showing such signs was immediately tested with an indicator male to determine whether or not she was sexually receptive. If the female proved to be receptive, she was placed in the experimental group A female which did not show external signs of oestrum was then selected from the same living cage and tested with an indicator male If she proved to be non-receptive she was placed in the control group When all of the available receptive females had been obtained upon any given day, they and their non-receptive controls were placed in small wire cages and carried into the experimental laboratory, which was an ordinary day-lighted room containing the apparatus to be used. The animals were allowed one hour for adaptation to the new surroundings before the test was begun In giving the test, the animals of the experimental and control groups were run alternately At the conclusion of the day's test, the animals were left in the experimental

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room for 48 hours and the test was then repeated. Immediately after this second test, each female was again placed with indicator males to determine her sexual condition, it being desired that both groups should be non-receptive at this second test. The experimental group was thus first tested when sexually receptive and retested two days later when non-receptive; while the animals of the control group were non-receptive at both tests. Eight females of the control group proved to be sexually receptive at the second test; they have been treated as a special experimental group since they were first tested when non-receptive but were sexually receptive at the retest two days later.

1 *Animals, Housing, and Diet*

A total of 159 pigmented female rats was used in the present study These animals had been sterilized by tying off the oviducts so that the animals had normal sexual cycles but could not become impregnated [1] To increase the number of females in heat available during the daylight hours, the rats were kept in a dark room with reversed lighting (i.e., artificial lights on during the night hours and off during the daylight hours) The animals were housed in cages measuring 30 by 15 by 13 inches (15 to 20 rats per cage), and were maintained upon a diet of dog chow supplemented with bread and milk, lettuce, and fresh meat

2 *Tests Used*

The main test (supplementary tests are described later) was the open field defecation test which has been used by Hall (5, 6) and Anderson (1, 2) in studies of emotionality in the rat. The apparatus consists of a circular open field 90 inches in diameter; the sides of the field are of sheet metal 30 inches high The rat to be tested is placed in the field by hand and left there for a test period of three minutes. The measure of emotionality or timidity consists of the number of fecal boluses excreted in the open field during the three minute test period A total of 159 pigmented females was tested in the open field, 72 of these were experimental animals, 79 controls, and 8 belonged to the special experimental group.

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[1] These operations were performed by F A Beach, Jr. in connection with his studies of sexual behavior in the rat The writer is indebted to Mr Beach for making these animals available for the present study

B. Results

The results of the open field test (Table 1) clearly show a reduc*tion in emotional defecation during the period of sexual receptivity*.

TABLE 1

Open Field Defecation Test

Showing the effect of sexual receptivity upon emotional defecation in the female rat. Scores are in terms of the number of fecal boluses excreted in a three minute test period. *Oest cond* = oestrous condition, *R* = receptive; *NR* = non-receptive

		Test 1		Test 2	
Group	*N*	*Oest Cond*	Mean Boluses	*Oest. Cond*	Mean Boluses
Experimental	72	*R*	4.14 ± .26	*NR*	5.19 ± .30
Control	*79*	*NR*	*5.77 ± .23*	*NR*	*4.91 ± .24*
Special Expt	8	*NR*	5.88	*R*	3.25

	Difference	Standard error of difference	Critical ratio
Test 1: Control minus Experimental	1.63	.51	3.20
Test 2: Control minus Experimental	—.28	.57	—.50
Experimental, Test 1 minus Test 2	—1.05	.40*	—2.62
Control: Test 1 minus Test 2	.86	.43*	2.00

*The correct formula for correlated measures was used.

The mean number of fecal boluses excreted by the 72 rats of the experimental group, tested when receptive, was 4.14, while the mean of the 79 control animals, tested when non-receptive, was 5.77 boluses. The difference between the two groups is 3.2 times its standard error. Thus sexually receptive females are less timid than non-receptive females. The reduction in emotional defecation induced by the sexually receptive state does not carry over to the retest given two days later. At this second test, given when both groups were non-receptive, the mean of the experimental group was 5.19 boluses, while the mean of the control group was 4.91 boluses. The difference of .28 between the two groups is only .5 times its standard error. The special experimental group of eight animals is too small to yield anything but suggestive results. It should be noted, however, that the first test was given to these animals when they were non-receptive and that their mean score of 5.88 boluses is very close to that of the control group. At their second test, these animals were receptive, and their mean score of 3.25 boluses is considerably below the second test score of either the experimental or control group. At least two factors favor reduction in score upon this retest: (*a*) the fact that the females were in heat, and (*b*) the fact that adaptation takes place when tests of this type are repeated. An estimate of the amount of reduction in score to be attributed to oestrum may be obtained by subtracting the first test score of the experimental group (4.14 boluses) from the first test score of the control group (5.77 boluses); this difference is 1.63 boluses. An estimate of the amount of reduction in score to be attributed to adaptation may be obtained by subtracting the second test score of the control group (4.91 boluses) from the first test score of the same group (5.77 boluses); this difference is .86 boluses. Now *if* these two factors summate, the amount of reduction in defecation to be expected when both factors are operating would be 2.49 boluses. The actual amount of reduction in the special experimental group is 2.63 boluses (5.88 — 3.25). This obtained result, then, would tend to suggest that these two factors favoring reduction in emotional defecation are additive.

The influence of oestrum upon defecation can also be shown by another method. For this treatment, the second test score of each animal was compared with the first test score of the same animal. In the experimental group, receptive at the first test, 54 per cent of the animals show an increase of score on the second test, 28 per cent show a decrease and 18 per cent made the same score on both tests. In the control group, non-receptive at both tests, 30 per cent show an increase of score on the second test, while in 50 per cent of the cases, the second test score was lower; 20 per cent of the controls made the same score on both tests. The difference between the per cent of animals in the two groups showing an increase in score is 3.04 times its standard error, while the critical ratio for the per cent of animals showing reduced scores upon the second test is 2.80.

So far, then, the data show a decrease in emotional defecation during oestrum, a result which has been interpreted as indicating a reduction in emotionality or timidity during the heat period. It is possible, however, that the decrease in defecation might be due to factors other than a decrease in emotionality. For example, female rats in heat are known to be more active in revolving drums than are females not in heat (11). *If* they are also more active in the open field situation, then a decrease in defecation might be due to a direct antagonism between the mechanisms of running and of defecation. This alternative explanation is at once ruled out because females in heat are not more active in the open field than females not in heat. To test this, the floor of the open field was marked off by chalk lines into 9-inch squares. During the same test period from which the defecation scores were obtained a record of the females' activity was obtained by counting the number of the squares traversed. The average exploratory activity score for the receptive females was 77.7 squares (Table 2), for non-receptive females, 76.9 squares. This difference is only .2 times its standard error. This result is not contradictory to the fact that females in heat are more active in revolving drums, since Anderson (*1*) has previously presented evidence that activity of the type measured in the open field may be best described as exploratory, rather than general, activity, *and that this exploratory activity is independent of the type of* activity measured in the revolving drum.

TABLE 2

OPEN FIELD EXPLORATORY TEST

Scores are in terms of the number of 9-inch squares traversed in a three minute test period. *Oest cond* = oestrous condition, *R* = receptive; *NR* = non-receptive.

Group	*N*	Test 1 *Oest Cond*	Test 1 Mean Squares	Test 2 *Oest Cond*	Test 2 Mean Squares
Experimental	72	*R*	77.7 ± 2.6	*NR*	56.1 ± 1.8
Control	79	*NR*	76.9 ± 1.9	*NR*	57.0 ± 1.8
Special Expt	8	*NR*	80.6	*R*	61.3

	Difference	Standard error of difference	Critical ratio
Test 1: Control minus Experimental	—8	4.72	—17
Test 2: Control minus Experimental	.9	3.75	.24

Other alternative explanations of the reduced defecation during oestrum might attribute the decrease in defecation to some of the *numerous factors such as metabolism change, fluctuations in* food and water intake, and so forth, which apparently vary with the oestrous cycle. A decrease in defecation in the open field might thus be due to variation in the amount of feces present at different stages of the cycle, and be quite independent of any change in emotionality. To test certain of these alternative hypotheses, three additional tests were used with smaller groups of animals. The females used in these supplementary tests had all been used in the open field test, but were not given more than one of the additional tests. The conditions of testing were as for the open field test, that is, the rats of the experimental group were first tested when in heat and were retested two days later when non-receptive; while the females of the control group were non-receptive at both tests.

1. *Supplementary Tests*

a. Water-wading defecation test (2). If the results of the open field test are due to the fact that females in heat contain a smaller amount of fecal material than non-receptive females, then it should follow that a somewhat stronger stimulating situation should not result in an increased amount of defecation in receptive females, whereas non-receptive rats should show such an increase. To test this, the water-wading defecation test was used. In this test, the rats are placed in a bottomless sheet metal box which is placed in a pan containing 1¼ inches of water. The rat is thus wading in

TABLE 3

RESULTS OF THE CONFIRMATORY TESTS SHOWING THE EFFECT OF SEXUAL RECEPTIVITY UPON TIMIDITY IN THE FEMALE RAT

Oest cond = oestrous condition, *R* = receptive, *NR* = non-receptive.

Water-wading Defecation Test

		Test 1		Test 2	
Group	*N*	*Oest.* cond	Mean Boluses	*Oest.* cond	Mean Boluses
Experimental	17	*R*	6.41	*NR*	7.00
Control	15	*NR*	8.67	*NR*	7.00
Emergence from Living Cage Test					
			Mean minutes		Mean minutes
Experimental	23	*R*	7.32	*NR*	12.70
Control	23	*NR*	11.15	*NR*	12.12
Emergence from Stove Pipe Test					
			Mean seconds		Mean seconds
Experimental	20	*R*	43.5	*NR*	71.7
Control	19	*NR*	47.6	*NR*	41.5

water in a dark box with no means of escape. The number of fecal boluses excreted during a three minute test period provides the measure of emotionality The results (Table 3) show a greater amount of defecation for both groups as compared with the open field test, and the same general relations hold as for the open field test that is, the receptive females defecate less than the non-receptive females (6.41 boluses compared to 8 67) upon the first test, while both groups made exactly the same score of 7 00 boluses upon the second test when all animals were non-receptive This test, then, would appear to confirm the interpretation in terms of a reduced emotionality during the time of oestrum For further confirmation, two tests not involving defecation were used.

b Emergence from living cage test (2) For this test the living cage of the rats was pulled out from its supporting shelves far enough to allow the rats free egress from the cage By climbing up the wire sides of the cage, the animals could escape through an opening (7 by 5 inches) in the top. The time required for the animal to thus emerge from the cage was recorded and used as the measure of emotionality It is assumed that rats which take a long time to emerge are relatively more timid The results of the emergence from cage test (Table 3) again confirms those obtained with the defecation tests; the receptive females take less time to emerge from their living cage than do the non-receptive females and the two groups make approximately the same score upon the second test.

c Emergence from stove pipe test (2, 9). The third confirmatory test was the stove-pipe test used by Stone (9) in studying wildness in rats The rats are required to run through a dark U-shaped tunnel made of 4-inch stove-pipe and to emerge into an open daylighted exit box The time required by the rat to thus emerge was used as the measure of emotionality, it being assumed that the more timid animals will remain in the dark tunnel a relatively long time. The results of this test are somewhat less satisfactory than those of the other tests. The females of the experimental group (Table 3) required less time to emerge when receptive than when non-receptive (43 5 seconds compared to 71 7 seconds) but the mean score of the animals of the control group is but slightly above that of the experimental group upon the first test and is considerably below that of the experimental group on the second test This discrepancy is probably due to original unequal emotionality of the animals in these two small groups

The general consistency of the results obtained with the supplementary tests appears to rule out the possibility that the results of the open field test were due to some artifacts and not due to an actual decrease in timidity. It is possible to interpret the results of the defecation tests as being due to changes in visceral excitability brought about by the oestrous condition. That is, if the threshold of visceral excitability (specifically, the mechanism of defecation) is raised during the heat period, then the females in heat might be expected to yield lower defecation scores (independent of changes in timidity) than the animals not in heat. If this explanation is applied to the defecation tests it would then be necessary to account for the results of the emergence tests in terms of a different principle, e.g., as being due to changes in general activity. On the basis of the present evidence it is not possible to exclude the explanation in terms of visceral excitability but the writer believes the data as a whole can be most adequately interpreted as indicating a reduction in timidity during the heat period.

C DISCUSSION

The reduction of timidity during the heat period may be interpreted in at least two ways. (*a*) The glandular changes associated with the receptive stage apparently bring about an increased sexual drive. It may thus be that the aroused drive or need tends to inhibit emotion as measured by the tests reported here. Results obtained by Hall (6) with the hunger drive confirm such an interpretation, since he found that hungry rats are less emotional in the field situation than non-hungry rats. Hall interpreted his results as indicating an inhibition of emotional behavior by the presence of a strong need. The results of the present study can readily be interpreted similarly. Hall also found that the reduced emotionality brought about by the hunger condition tended to persist even when the animals were not hungry. In the present study, no such permanent adjustment was found, but it should be noted that the number of repetitions in this study is much less than in Hall's.

(*b*) The second interpretation of the reduced timidity of the female during the receptive period involves the assumption that the glandular changes associated with oestrum not only affect the sexual drive, but also act directly to reduce emotionality. The reduced timidity during the receptive stage would then be due, not to an inhibition of emotion by the presence of a strong need, but rather to some more direct effect of the glandular changes upon the mechanisms of emotion. Evidence to be presented in a later paper (3) suggests that such may be the case, and that glandular changes *associated with the sexual hormones may result in a decreased emo*tionality even when no drive is present

Varying results obtained in comparing male and female rats upon such tasks as maze performance[2] may in part be due to changes in emotionality associated with oestrum That is, if the experimental *conditions are such that emotional factors may play a relatively large* rôle in determining the performance, then the reduction in timidity during the heat period might be of sufficient importance to result in better performance by the female group. That such an improvement need not necessarily occur under all learning conditions is *indicated by Ball's (4) study in which no significant differences* were found between females learning a maze when in oestrum and females learning the same maze when in dioestrum Previous studies have shown that various functions such as activity (11), reflex time (7), and metabolism (8) may fluctuate with the oestrous cycle The present study establishes a change in timidity or emotionality during the receptive state. The use of the female animal in some types of experimentation may therefore lead to the introduction of several more or less uncontrolled variables This fact makes the female rat a somewhat undesirable animal for general experimentation and casts some doubt upon the general procedure of using mixed groups of male and female animals for experimental and control groups. These considerations also cast doubt upon the use of mixed groups of animals in correlational studies Apart from the danger of the existence of sex differences which might affect correlations, it is possible that the inclusion of female rats which may be given the various tests at different stages of the oestrous cycle may markedly affect the obtained correlations If, for example, the performance upon two different tests may in part be influenced by functions (such as activity or timidity) which vary with the oestrous cycle, then any correlation between the two tests could be obscured by the fact that the females may differ in the stage of oestrous at which they are given the tests. In general, then, the possibility of uncontrolled variables introduced by the use of female rats should be considered in evaluating experimental results

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[2] The studies have been reviewed by Tomlin and Stone (10)

D SUMMARY

1. Female rats are less timid (as measured by several tests) when sexually receptive than when non-receptive.

2. The reduction in timidity during the heat period may in part be due to the inhibition of emotional behavior by the presence of a strong drive, but may also be due to the direct action of the glandular changes associated with oestrum upon the mechanisms of emotionality.

3. It is pointed out that several functions, such as activity and timidity, are known to vary with the oestrous cycle, and that the use of female rats in experimentation therefore tends to introduce several known uncontrolled variables

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THE SEX HORMONES AND EMOTIONAL BEHAVIOR. II. THE INFLUENCE OF THE FEMALE SEX HORMONE UPON TIMIDITY IN NORMAL AND CASTRATED FEMALE RATS*

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A. INTRODUCTION

In the first paper of this series (3) it was shown that there is a reduction of timidity during the sexually receptive stage of oestrous in the female rat. Two interpretations of this decreased timidity were suggested: (*a*) The glandular changes associated with oestrum result in an increased sexual drive, and this drive may inhibit emotion; (*b*) the glandular changes may act directly upon the mechanisms of emotion to reduce timidity, rather than indirectly through the sexual drive. The present study is an attempt to obtain data which will aid in choosing between these two hypotheses. The problem is to produce glandular changes similar to those occurring during the sexually receptive state without, however, producing sexual drive.

The glandular changes assumed to be similar to those occurring during oestrum were produced by injections of the female sex hormone (*Progynon-B*, Schering). Fortunately, this hormone produces different results in castrated and normal females. In the castrate (1), injection of the sex hormone results in the vaginal smear typical of the receptive stage of oestrus [Long and Evans (6), Stage 2]. This condition may be continued as long as the hormone is regularly injected. In the normal female, on the other hand, continued daily injections of the female sex hormone in the proper dosage may produce one heat period, but there is then, for a time, a persistent and continuous dioestrous state (5).[1] It is thus possible to supply both groups of animals with an excess of the sexual hormone while obtaining a marked difference in the oestrous stage as indi-

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[1] If the injections are continued long enough, the female may again show the smears typical of oestrum (5). In the present study, injections were stopped before this stage of renewed oestrum was reached.

cated by vaginal smears. With reference to the theories to be tested, then, certain deductions would appear to follow. If the reduced timidity during oestrum is due to the inhibition of emotion by drive (Theory 1, above), then castrated females injected with sex hormone so as to produce the typical smear of oestrum[2] should be less timid than control castrates. With the normal females, on the other hand, injections of the sex hormone result in the dioestrous smear and presumably no sexual drive is present. Consequently, no change in timidity is to be expected over control normals in the dioestrous stage The second theory (Theory 2, above) suggests that the glandular changes associated with oestrum result in decreased timidity independently of the presence of the sexual drive This theory would therefore require that both the normal and castrate female groups injected with the sex hormone should show a decreased timidity, since the required glandular changes are being produced although the oestrous stages vary markedly in the two groups. The two theories thus agree in the expectation of reduced timidity in the injected castrates but disagree as to the result to be expected with normal females injected with the sex hormone.

B Procedure

The test of timidity used throughout the present experiment was the water-wading defecation test previously described (2). The animal to be tested is placed in a bottomless sheet-metal box 12 by 10 by 13 inches high which is placed in a pan containing 1¼ inches of water at room temperature A sliding sheet-metal door at the top of the box is used to introduce the rat into the apparatus and prevents escape by jumping The rat is thus wading in water in a dark box with no means of escape. The emotional score consists of the number of fecal boluses excreted during a three-minute test period.

1. *Animals*

a Castrated groups. All females of the castrated groups were ovariectomized under deep ether anesthesia at 32 to 46 days of age.

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[2] This argument assumes that the cornified smear gives some indication as to the presence of the sexual drive. Ball (4) has pointed out that smears are not perfectly correlated with behavior, and therefore some error may arise from the use of smears as the criterion of drive in the present study This criticism is considered later in the section devoted to discussion

They were 117 days old at the beginning of the first series of six tests of the present experiment. Two groups of nine animals each were selected from a larger group of castrated females upon the basis of a series of six daily water-wading tests (Series 1) given in connection with another experiment The groups were so formed that each animal of Group *A* was matched by an animal in Group *B* which had made approximately the same defecation score (number of fecal boluses excreted) on the series of six tests Thirteen days after this series of tests, castrate Group *A* was given daily subcutaneous injections of 25 *R U* of the female sex hormone (*Progynon-B*, Schering) in 2 cc. of sesame oil After six daily injections a series of four daily tests (Series 2) was given in the water-wading apparatus, the daily injections of hormone being continued during this test period. Group *B* served as a control group during this test period, being treated exactly as Group *A* with the exception that the daily injections consisted of 2 cc of sesame oil without the sex hormone. After this second series of defecation tests, the animals were rested for 24 days, then given 10 days of daily injections, a series of four daily water-wading tests (Series 3) being given on the last four days of injections. In this second series of injections the groups were reversed, Group *A* now receiving the control injection of sesame oil and Group *B* receiving the sex hormone.

b. Normal groups. A large number of normal pigmented females (117 days old) were given a series of six daily tests (Series 1) in the water-wading apparatus in connection with another experiment On the basis of the scores made in this first series, two groups of 12 females each were selected so as to be equally matched in their defecation scores. Thirteen days after this series of tests normal Group *A* was given daily subcutaneous injections of 25 *R U* of the female sex hormone in 2 cc. of sesame oil. After six days of injections[3] a series of four daily tests (Series 2) was given in the water-wading apparatus, the daily injections of hormone being continued during this test period Group *B* served as a control group during this period, being treated exactly as Group *A* with the exception that the daily injections consisted of .2 cc. of sesame oil without sex hormone At the conclusion of this second series of tests, the animals rested for 24 days, then followed 10 days of daily injections, a series of four water-wading tests being given (Series 3) on the last four days of injections. At this second series of injections, the groups were reversed, Group *A* now receiving the control injection of sesame oil and Group *B* receiving the sex hormone. The animals of these two groups were again allowed to rest for 27 days and were then given a final control series (Series 4) of four daily water-wading defecation tests, no injections being given to either group.

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[3] The number of daily injections of hormone was given before testing was begun in order to insure that the normal females would show dioestrous smears throughout the series of daily tests.

Vaginal smears were taken daily from all animals, both normals and castrates, during the period in which they received either control or hormone injections. When behavioral tests were being given, injections and the taking of smears always followed the emotional test.

C. Results

1. *Castrated Groups*

The scores in terms of the mean number of fecal boluses excreted per daily test for the various series of tests given the castrate Groups *A* and *B* are presented in Table 1. It will be noted that the animals receiving sex hormone, Group *A*, Series 2, defecate somewhat less (3.67 boluses) than the control animals, Group *B*, Series 2, of this

TABLE 1

Emotional Defecation of Castrated Female Rats in the Water-Wading Test as Influenced by the Injection of the Female Sex Hormone

Series 1 consists of six daily tests of three minutes each; all other series consist of four daily tests of three minutes each. Scores are in terms of the mean number of fecal boluses excreted per daily test

		Series 1		Series 2		Series 3	
	N	Injection	Mean boluses	Injection	Mean boluses	Injection	Mean boluses
Group *A*	9	None	5.26	Hormone	*3.67*	Control oil	4.56
Group *B*	9	None	5.35	Control oil	3.92	Hormone	*2.72*
Difference							
Control minus hormone					.25		1.84
Standard error of difference*					.68		.89
Critical ratio					.37		2.07

*Since the groups were originally paired, the standard errors were calculated from the differences between paired animals, using appropriate formulae for small groups.

period (3 92 boluses) When the treatment given the two groups is reversed, the rats receiving sex hormone (Group *B*, Series 3) again yield a lower emotional score (2 72 boluses) than the control animals (Group A, Series 3; 4 56 boluses) All of these values lack statistical significance (Table 1) but the consistency of the results argues for the existence of a real effect of the hormone, especially in view of the reversal of the treatment given the two groups. In so far, then, as it is safe to argue from data which are consistent but lack statistical significance because of the small size of the groups involved, the injection of the female sex hormone into castrated females results in a decrease in timidity as compared with control castrates

a. Vaginal smears Throughout the period of hormone injection, all castrated females yielded the cornified smears of oestrum During the control periods, all smears were those of the typical non-injected castrated female

2 *Normal Groups*

The results for the normal Groups *A* and *B* are presented in Table 2 It is again to be noted that the injection of the sex hormone consistently results in a decrease in emotional defecation The results again lack statistical significance, but several facts argue strongly that the obtained differences are real and not due to chance

(*a*) The general consistency of the results, i.e., the group receiving hormone was below the control group in both Series 2 and 3 The fact that the treatment given the groups was reversed for Series 2 and 3 strengthens this argument

(*b*) The two groups were paired upon the basis of the scores made in the six tests of Series 1. Twelve weeks later the two groups made almost exactly the same score upon the control Series 4 (Table 2)

(*c*) In both groups, the experimental hormone series is followed by an increased score (in the same group) at the next control series; i.e., Group *A* averaged 3 79 boluses when receiving sex hormone (Series 2), four weeks later, receiving a control injection (Series 3) the average for Group *A* was 4.02 boluses Group *B* averaged 2 81 boluses when receiving hormone (Series 3) and 2 88 boluses when receiving control injections (Series 4). Although small, these increases at subsequent tests would appear to be especially significant

TABLE 2

Emotional Defecation of Normal Female Rats in the Water-Wading Test as Influenced by the Injection of the Female Sex Hormone

Series 1 consists of six daily tests of three minutes each; all other series consist of four daily tests of three minutes each Scores are in terms of the mean number of fecal boluses excreted per daily test.

		Series 1		Series 2		Series 3		Series 4	
	N	Injection	Mean boluses	Injection	Mean boluses	Injection	Mean boluses	Injection	Mean boluses
Group *A*	12	None	5.85	Hormone	*3.79*	Control oil	4.02	None	2.94
Group *B*	12	None	5.82	Control oil	4.19	Hormone	*2.81*	None	2.88
Difference									
Control minus hormone					40		1.21		
Standard error of difference*					1.11		1.23		
Critical ratio					36		93		

*Since the groups were originally paired, the standard errors were calculated from the differences between paired animals, using appropriate formulae for small groups since the test in general shows adaptation when later series are presented.

These various facts, then, support the interpretation that injections of the sexual hormone result in a decreased timidity as measured by the defecation test However, the results can only be considered *suggestive since they lack adequate statistical significance*

a. Vaginal smears With one exception, normal females during the test period of injection of sexual hormone showed the smear typical of dioestrous. During the control injection periods, the smears were normal, i e, they showed the complete range in the cycle as described by Long and Evans.

C Discussion

In spite of the lack of statistical significance, the general consistency of the results supports the second theory proposed That is, the glandular changes brought about by the injection of the female sex hormone appear to result in a reduction in timidity[4] regardless of whether or not the sexual drive is aroused. In an earlier section (Footnote 1) it was noted that the cornified smear gives only an inadequate index of the presence of heat behavior, and that it is possible that the sexual drive was not aroused in the present castrated injected group. It might therefore be argued that the present experiment is an inadequate test of the theory that the reduction in timidity during the heat phase of the normal female is due to an inhibition of emotionality by the presence of a drive It was previously pointed out, however, that such a theory would imply that the normal injected groups of the present experiment should not show a reduction in timidity as compared with their non-injected control normals If the castrated injected females are considered not to be sexually aroused, then they, also, would not be expected to show a reduction in timidity score Both of these implications are apparently contradicted by the results of the present experiment. It is possible, of course, that the two theories should not be treated as antagonistic, since the glandular changes might result in a reduction in timidity without the presence of a drive (Theory 2), but the presence of the drive might result in a still greater reduction in emotionality (Theory 1). If such a combination of factors takes place one would expect normal females during oestrum (glandular changes plus drive) to show a greater reduction in timidity than normal females injected with the sex hormone (glandular changes alone). The scores to be expected for injected castrate animals would depend upon whether or not the sexual drive was aroused. The data so far obtained are not adequate to completely solve this problem, but such comparisons as can be made seem to indicate that some such combination of factors may take place. The comparisons have been made as described below.

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[4] It is possible that the reduction in defecation scores brought about by the hormone injections may be due to changes in visceral excitability rather than to changes in timidity That is, if the threshold of excitability of the mechanism of defecation is raised by the hormone injections, then a reduction in defecation score would be expected independently of any change in timidity The writer has favored the interpretation in terms of change in timidity, but the alternative explanation cannot be ruled out on the basis of present evidence.

1. *Normal Females in Oestrum*

In the first paper of this series (3) of papers, normal females in oestrum averaged 4.14 boluses on an open field defecation test while females not in heat averaged 5.77 boluses. The difference of 1.63 boluses is a reduction of 28 per cent of the control value. In the same experiment a water-wading test yielded averages of 6.41 and 8.67 boluses for females in heat and not in heat respectively. The difference of 2.26 boluses is a reduction of 26 per cent of the control value. Oestrum, then, appears to result in a decrease in timidity of about 27 per cent.

2. *Normal Females Injected with Progynon-B*

Unfortunately, the amount of reduction in defecation score produced by *Progynon-B* was not the same in Series 2 and Series 3. A somewhat inadequate measure of the amount of decrease has been obtained by combining the score made by Groups *A* and *B* when given hormone (3.79 + 2.81 = 6.60 boluses) and comparing this value with the score made by Groups *A* and *B* when serving as controls (4.19 + 4.02 = 8.21 boluses). The difference of 1.61 is a reduction of 19.6 per cent of the control value. This value is somewhat below that for the normal female in oestrum and thus may indicate that the presence of the sexual drive results in a greater decrease in timidity than can be accounted for in terms of glandular activity alone.

3 *Castrated Females Injected with Progynon-B*

The measure of amount of decrease in emotionality was obtained in the same way as for the normal groups. The combined score for hormone treatment is 6.39 boluses as compared to the combined control score of 8.48 boluses. The difference of 2.09 boluses is a reduction of 24.6 per cent of the control value. This figure is quite close to the decrease produced in normal females by oestrum, and somewhat greater than the decrease produced by *Progynon-B* injections in normal females.

Because of the small number of animals in some of the groups, the above comparisons can be considered as only suggestive at best. They do, however, suggest that the female sex hormone appears to produce a decrease in timidity of about 20 per cent, even though the sexual drive is not aroused, and that the presence of the drive along with the glandular changes may result in a further decrease in emotional score of from 5 to 8 per cent.

The reduction of timidity during the heat stage of the oestrous cycle (3) thus appears to be due to some inhibition of emotionality by the aroused sexual drive plus some action of the hormone which affects the mechanism of emotionality independently of the drive state. The latter factor appears to be of considerably more importance than the first. The mechanism by which the female hormone acts to reduce timidity is at present not clear, but the writer is inclined to believe that the action is indirect and probably involves the pituitary gland rather than being a direct result of the effect of the female hormone upon the mechanism of emotionality.

D. SUMMARY

1. In both normal and castrated female rats, injection of the female sex hormone appears to result in a reduction in timidity, although the results are not statistically significant.

2. The results are considered in relation to two theories concerning the effect of oestrum upon timidity.

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THE SEX HORMONES AND EMOTIONAL BEHAVIOR: III. THE EFFECT OF CASTRATION UPON TIMIDITY IN MALE AND FEMALE RATS*

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A. INTRODUCTION

In the first paper of this series (2) it was found that females in heat were less timid or emotional than females not in heat. In the second paper (3), the evidence indicated that injection of the female sex hormone into either normal or castrated females results in some reduction in timidity. Because of the comparable effects of the female sex hormone upon normal and castrated animals, the results were interpreted as indicating that the reduction in timidity during oestrum was largely due to some action (either direct or indirect) of the female hormone upon the mechanisms of emotionality. The evidence presented has thus indicated a temporary change in emotionality of the female rat due to action of the female sex hormone. The present experiment was designed to test whether or not this change in timidity induced by the sex hormone might also be permanent. If the sex hormones play a rôle in determining the general and relatively permanent level of emotionality or timidity, then animals castrated before puberty might be expected to have a different emotional level than normal animals. On the other hand, if the general level of timidity of an animal is independent of the action of the sex hormones, then no difference between normal and castrated animals would be expected.

With the male rat the writer (1) has reported negative correlations ranging from —.34 to —.58 between measures of sexual drive and emotionality or timidity. The sign of the coefficient means that a high degree of sexual drive is associated with a low degree of timidity. Since castration ultimately results in a loss of sexual drive (7) it might appear that castration should result in an increase in timidity. However, such a result would follow only if the sex

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glands themselves are important determiners of individual differences in both sexual and emotional behavior. The present experiment demonstrates that neither male nor female rats castrated at an early age are more timid than normal rats.

B. PROCEDURE

1. *Animals*

a. Female groups. A total of 43 castrated and 40 normal pigmented female rats was used. At 32 to 46 days of age, half of the females of a given litter were placed in the normal group and the other half were castrated. All operations were performed under deep ether anesthesia and aseptic conditions. The animals were housed (five per cage) in mesh wire cages measuring 13½ by 12 by 12½ inches, and were maintained upon a diet of dog chow supplemented with fresh meat and lettuce.

b. Male groups. A total of 42 castrated and 42 normal pigmented male rats was used in the present experiment. At 28 to 41 days of age, half of the males of a given litter were placed in the normal group and the other half were castrated under deep ether anesthesia and under aseptic conditions. Housing and maintenance were as for the female groups, males and females being caged separately.

Both male and female groups were 112 days old (range 100 to 116 days) at the beginning of the present experiment.

2. *Tests Used*

Three tests of emotionality or timidity were used:

a. Open field defecation test. This test has been previously described by Hall (5) and Anderson (1). The rat to be tested is placed in a circular open field 90 inches in diameter and left for a period of three minutes. Two such 3-minute tests were given with a 4-day interval between tests. The score is the mean number of fecal boluses excreted during the test periods.

b. Water-wading test (1). The animal to be tested was placed in a bottomless sheet-metal box 12 by 10 by 13 inches high which was placed in a pan containing 1¼ inches of water. A sheet-metal sliding door was used for introducing the animal into the apparatus. The test period was three minutes in length and the emotional score consists of the number of fecal boluses excreted The first water-wading test was given on the day following the second open field test Six daily tests were given in the water-wading apparatus.

c. Emergence from living cage test (1). For this test, the mesh wire living cage of the animals was pulled forward from its supporting shelves to allow free egress from the cage through a 5- by 7-inch hole in the top of the cage A stop watch was started when the cage was pulled forward and the time was recorded when a rat came out on top of the cage The test was continued until all five rats of a given cage had thus emerged or until 20 minutes had elapsed, at which time the test was discontinued and all animals still remaining in the cage were given the maximum score of 20 minutes. The first emergence test was given 10 days after the conclusion of the water-wading test, the test being repeated daily for four days. Not all of the animals were given the present test, the number being indicated in the appropriate tables.

In all of the above three tests, a low score indicates less timidity The apparatus used was duplicated, and males and females were not tested upon the same piece of apparatus

C. RESULTS

1 *Female Rats*

The results for the female groups are presented in Table 1 None of the three tests of timidity shows a significant difference between the normal and castrated animals. The two defecation tests yield differences which are opposite in direction and which are less than one times their standard error In the emergence from cage test, the normal females made an average score considerably below that of the castrated animals. The difference is probably large enough to merit some consideration since it is 2 1 times its standard error. Unfortunately, the emergence from cage test is not an unambiguous measure of timidity or emotionality since it probably involves activity and other factors as well as emotionality. Since castrated females are known to be less active than normal females (6), such differences as were obtained with the present test may be due to differences in the activity level of the two groups.

TABLE 1

Comparison of Normal and Castrated Female Rats Upon Three Tests of Timidity

The open field and water-wading tests are scored in terms of the number of fecal boluses excreted, the emergence from living cage tests in terms of minute to emerge from the cage

Test	No tests	Normal N	Normal Mean	Normal σ_{mean}	Castrated N	Castrated Mean	Castrated σ_{mean}	*Diff.**	$\sigma_{diff.}$	D/σ_{diff}
Open field	2	40	3.23	.87	43	3.84	.80	—.61	1.18	—.52
Water-wading	6	40	25.51	2.46	43	23.18	2.60	2.33	3.58	.65
Emergence from cage	4	30	22.73	4.44	33	35.66	4.16	—12.93	6.09	—2.12

*A minus sign indicates that the normal group made the lower score

TABLE 2

Comparison of Normal and Castrated Male Rats Upon Three Tests of Timidity

The open field and water-wading tests are scored in terms of the number of fecal boluses excreted, the emergence from living cage in terms of minutes to emerge from the cage

Test	No tests	Normal N	Normal Mean	Normal σ_{mean}	Castrated N	Castrated Mean	Castrated σ_{mean}	*Diff**	σ_{diff}	D/σ_{diff}
Open field	2	42	5.98	.84	42	6.74	.84	—.76	1.19	—.64
Water-wading	6	42	29.86	2.08	42	28.36	2.17	1.50	3.01	.50
Emergence from cage	4	30	58.32	3.80	32	53.70	4.18	4.62	5.65	.82

*A minus sign indicates that the normal group made the lower score

2. *Discussion of Female Groups*

In view of the inconsistent and statistically non-significant differences obtained with the various tests used, the results can probably be best interpreted as indicating no true difference in timidity between normal and castrated female rats If this interpretation is correct, a somewhat paradoxical situation appears, i e, while castration does not increase timidity, the presence of changes brought about by the sex hormone either during normal oestrum (2) or by injecting the hormone (3) appears to result in a decrease in timidity In other words, the presence of the hormone reduces timidity, but the complete absence of the sex glands does not increase timidity. This seeming paradox can probably be interpreted as follows: the emotional level or degree of emotionality of a given animal does not depend upon any action of the sex hormones Therefore castration at an early age does not affect the timidity score. On the other hand, once the general level of emotionality is established, various factors may operate to change the degree of emotionality temporarily The earlier papers of this series (2, 3) indicate that the female sex hormone is one such factor that may temporarily decrease the amount of timidity displayed in the female rat

3 *Male Rats*

The results are presented in Table 2 All differences are slight and not statistically significant. The normal males are slightly less emotional in the open field test while the castrated males give the lower scores in the water-wading and emergence from cage tests

4 *Discussion of Male Groups*

The results show a complete absence of the effects of castration upon timidity in the male rat It is thus indicated that the sex glands are not determiners of individual differences in emotional behavior The source of the negative correlations between sexual drive and timidity in the male rat must therefore be sought elsewhere than in the sex glands. Although the evidence at present is incomplete and inadequate, the writer is inclined to believe that the pituitary gland is one important factor in determining the relation between sexual and emotional behavior It is known that the pituitary gland secretes at least two hormones which influence the sexual glands It is therefore quite possible that individual differences in sexual drive are in large part dependent upon differences in functional capacity of the hypophysis. The sexual glands might thus play a necessary part in sexual behavior, but the ultimate source of individual differences would lie in the pituitary gland rather than in the gonads. That the pituitary gland may also play a rôle in the determination of individual differences in emotional behavior has been suggested by some evidence obtained by the writer (4). In addition to the glandular factors, it is also probable that neural factors may be involved in the relation between emotional and sexual behavior In any case, the present experiment rules out the gonads as a source of the relation.

D. Summary

1 Castrated and normal rats of both sexes were compared on three tests of timidity.

2. No significant differences in timidity were found between castrated and normal rats of either sex.

3 The data are considered with reference to results previously reported.

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THE GENETIC DEVELOPMENT OF THE ASSOCIATIONAL STRUCTURES OF ABSTRACT THINKING*

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A INTRODUCTION

1 *The Term "Abstract Thinking"*

By abstract thinking we mean the ability to include several or many smaller concepts in one large concept at the linguist level For example, the ability to think of this thing as a cat, that thing as a dog, another as a cow, and to think of all of them as comprising the class of animals, not sub-linguistically, but at a level at which we attach labels to all of these concepts The philosophic mind might be inclined to stretch the meaning of abstract thinking so as to include the sub-linguistic activity which enables the infant to behave as though he understood the distinction between food and non-food and at the same time manifest a preference for one type of food instead of another.

We are willing to concede this expansion of the term abstract thinking, provided one realizes that linguistic activity requires a much higher mental development. We are interested mainly in the linguistic type and in the various levels of abstract concepts which go to make up hierarchical structures The class *"Fruit"* includes apples, pears, etc., and the class *"vegetable"* includes potatoes, peas, etc Fruit and vegetables thus are abstract concepts of the first order They in turn may be species of a more inclusive class *"Food"* which in this relationship would stand as a concept of the second order. The structures of our natural sciences often constitute hierarchies of as many as eight or nine levels.

2 *The Preliminary Investigation*

Our first investigation of the genetic development of abstract thinking consisted in studying the language development of five children

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of the Home for Hebrew Infants (N Y. C.) from their 12th month to their 26th month, on alternate days The group consisted of three boys and two girls with *IQ*'s ranging from 76 to 110. On alternate days a list of 25 words was taught them. That is to say, the word for each object and act on the list was repeated from 30 to 70 times, while *the object* was carefully displayed to the child or he was made to perform *the act*. In some cases it required several thousand repetitions before the children showed a knowledge of a word. When the children were 19 or 20 months old and had an average subvocal vocabulary of 15 words we began to teach them the genus and species of flowers, animals, chairs, and balls The perceptible differences in the species of the first two groups were quite slight, but were very great in the last two.

The species we used in the *"chair"* group were a straight upright chair and a collapsed folding chair; in the *"ball"* group, a red ball, 8" in circumference and a ball of similar size and color in a collapsed state The "animal" group consisted of a turtle, a hippopotamus, a seal, and a sheep. The colors differed except in the case of the seal and the hippopotamus The turtle was very much smaller than the rest. The other animals were roughly about 4" long and 2" high. The flowers were a large yellow chrysanthemum, a pointsettia with red felt finger-like petals, a white pointsettia, a wild rose (dark orange), and a small pompom chrysanthemum with a blue center and brown leaves. The species names and genus names of all of these objects were of one syllable. In the *"ball"* group the genus symbol was taught first, and in the *"chair"* group the species symbols were taught first, while both the genus and species names of the *"animal"* and *"flower"* groups were taught simultaneously.

In teaching the children abstract concepts we repeated the species and class symbols the same number of times during any test period We tested for subvocal knowledge of any species symbols by having the child identify the object in a group of like objects when the correct symbol was given The child was credited with knowledge upon the correct identification three times in succession on three alternate days. We tested for subvocal knowledge of the class symbols by placing one member of a class (for example the turtle) in a group of extra-test objects and by giving the class symbol This involved nine trials in which the class symbol was repeated three times in among symbols for other objects.

Another test for abstract knowledge consisted in asking for the class when only members of that class were present In this type of test the child was irregularly called upon nine times to identify the class as a whole and two different species This shift from identifying an object in one situation when the class symbol was given, to identifying the same object in another situation when its species symbol was given, and to identifying the group as a whole in this second situation when the class symbol was given, kept the scores of the children extremely low, yet this was the only way that we could make certain they understood genus and species phenomena at the linguistic level.

From their 20th to their 23rd month these children were conditioned and tested no more than once a week. From their 24th to their 26th month they were conditioned and tested on alternate days By the end of six months they knew no more concerning genus and species than they did in the beginning If the training had any effect on them it was to retard them, since it seemed to destroy their motivation completely During the first three months of the experiment we found that our children could not retain both the genus and species symbols for any of our test material They learned neither the genus nor the species symbols when taught at the same time. In other instances, if the children first learned the class symbol and were later taught the species symbols, they were either completely confused by this additional training or else learned the species symbols and forgot the class symbol The same was true when we first taught them the species symbols and later the genus symbol

Our next investigation was along totally different lines and involved widening somewhat the scope of our inquiry It is this phase of our work that we are presenting in detail

B. The Present Problem

The questions which we have attempted to answer in this study are: (*a*) When do children normally begin to learn abstract concepts? (*b*) At what rate does their vocabulary of abstract concepts normally increase? (*c*) How much training is necessary to teach children of 3, 4, 5 and 6 years of age abstract concepts of the 1st, 2nd and 3rd order? (*d*) What section of the hierarchical structures supporting second and third order concepts does the child find the most difficult in the process of learning?

Two different types of technique were used which divided the study into two separate parts. The first consisted of an identification and questionnaire test, the second of a conditioning test.

C. THE IDENTIFICATION AND QUESTIONNAIRE TESTS

1. *The Procedure*

a The material and method of testing The materials for the identification test were a toy dog, a cow, a horse and a pig, a soldier and a nurse, a hat, coat and shoes, a chair and table, a carrot, and a potato, an apple, a banana and an orange. The smaller materials were spread on a table The child was asked to identify at least two animals, the toy man and woman, two vegetables, two fruits, and the two pieces of furniture when these species names were given. After that he was asked to identify group concepts. For instance, he was asked to place the *"animals"* over in one corner of the table and to give them all of the *"vegetables."* The toys were then mixed up and he was asked to put the *"people"* over in another corner of the table and to give them *"fruit"* He was also asked what *"furniture"* he liked the best and to show the experimenter his *"clothes"* He was asked to pick up the *"soldier"* and the *"nurse"* and to collect all of the *"food"* in his lap. If the child manifested knowledge of the animals, people, clothes, furniture and food concepts in relation to their respective species, he was given credit for understanding five first order abstract concepts. If in addition, he properly identified the fruit and vegetables, the soldier and the nurse, he was given credit for a knowledge of two second hierarchy concepts (e g., second order *food,* including first order *fruits* and first order *vegetables—fruits,* including bananas, oranges—*vegetables* including potatoes, carrots; and second order *people,* including first order *man* and first order *woman—man* including soldier and *woman* including nurse). The total number of points for this test was eight.

The following questions are taken from the questionnaire.

1. Have you any *animals or pets* at home? (The child was credited with one point if he mentioned the name of any *breed*)
2. What *games* do you like to play? (One point)
3. What *color* is my hand—and my hair? (One point credit if the correct colors were mentioned.)
4. What kind of *food* do you like best? (One point credit if he failed to recognize the food concept in the identification test.)

5 What kind of *meat* do you like? (One point)
6. What do you like to *drink?* (One point)
7. What do you *eat with?* (One point)
8 What kind of *tools* has your daddy? (One point)
9 What kind of *boats* do you like? (One point.)
10 What kind of *toys* do you like? (One point)
11 What kind of *weather* do you like? (One point)
12 What kind of *flowers* do you like? (One point credit if the child mentioned an actual species and none if he merely showed color preference)
13 What is your favorite *color?* (One point credit if he gave the correct answers for Question 3)
14. What kind of *children* do you like? (One point credit for any rational modification Credit was given for distinctions between white and black children, but obviously none for modifications such as "blue children" as we sometimes received)

The identification and questionnaire tests were given in conversational form over a period lasting from 15 to 20 minutes. The total number of points for both tests was 21. The three second order concepts were *food, people,* and *animals* (including dogs, and a special breed of dogs)

b. The subjects. There were 93 subjects in all ranging in age from 21 to 72 months, from the following institutions[1] which we shall describe in Table 1.

c. The socio-economic status The only institutional children in this whole group were those from the Home for Hebrew Infants. The *socio-economic* status of most of the non-institutional children was about the same Perhaps that of the Hunter Model school children was a little higher than the others

d Intelligence ratings. Most of the intelligence ratings are taken from the files of these institutions The children from the Normal Child Development Study, the Home for Hebrew Infants, and the Manhattanville Day Nursery were given the revised Binet test

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[1] I wish to express my gratitude to Dr Myrtle McGraw of the Normal Child Development Study, to Dr D J. McCune of the Child Clinic of the Babies Hospital, to Dr L Barenberg, Miss Mary Creed and Dr R Rippin of the Home for Hebrew Infants, and to Miss E A Webster of the Manhattanville Day Nursery, for their courtesy and cooperation in allowing me to give these tests and for giving me testing rooms. I am also indebted to Mrs. Mary Lukomnik for her assistance and for her many valued suggestions, as well as to Miss Ruth Leder for her occasional aid.

TABLE 1

Institutions	Age range in months	Boys	Girls	Total
The Normal Child Development Study of Columbia University	21-72	7	7	14
The Child Clinic The Babies Hospital (N Y C.)	21-36	10	7	17
The Home for Hebrew Infants (N. Y C)	35-44	8	4	12
The Manhattanville Day Nursery (N Y C)	21-62	22	16	38
The Hunter Model School (N Y. C)	66-72	4	6	10
Home children	(21 & 42)	1	1	2
		52	41	93

The Hunter Model School children were given the Pintner-Cunningham Group test. We were not able to obtain any ratings from the clinic children, since none were made previously and their parents pressed us for time

e *Terms used in Table 2*

(1). *"Individual 1st H. Vocabulary."* This column contains the number of first order abstract words which each child knew.

(2). The columns to the right of the above give the number and averages for boys and girls

(3) *"1st H group average"* This column contains the average of the entire group of each age level.

(4) *"2nd H. Vocabulary."* This column contains the number of second order abstract words which each child knew.

2 *The Results*

a In Figure 1 it will be noted that the greatest gain was between the 34-39-month level and the 40-46-month level. The gain between the 59-64-month level and the 65-72-month level was almost as high. Between the 47-52-month level and the 53-59-month level there was a fractional decline.

b Four out of 21 children between 34 and 46 months of age, and 18 out of 29 between 47 and 64 months of age, manifested knowledge of at least one second hierarchy concept. Only three children below 5½ years showed a knowledge of two second hierarchy concepts, while all of the 10 children over 5½ years understood two, and four of them understood three second hierarchy concepts.

TABLE 2

Subject	Sex	*IQ*	Age	Individual 1st *H* vocabulary	*Boys* *N*	*Boys* *M*	*Girls* *N*	*Girls* *M*	1st *H* group average	2nd *H* vocabulary
	21 to 26 months									
1	girl	120	21	0						
2	boy		21	0						
3	boy		21	0						
4	boy		21	2						
5	girl		22	3						
6	girl		23	2						
7	girl		24	0						
8	boy		24	1						
9	boy		24	2						
10	girl		26	1						
11	boy		26	1						
12	girl	96	26	2						
					6	1.00	6	1.33	1.16	
27 to 33 months										
13	girl		27	0						
14	boy		28	1						
15	girl		28	2						
16	boy		29	1						
17	girl		30	6						
18	girl		30	8						
19	boy		30	10						
20	boy		32	0						
21	girl		32	7						
					4	3.00	5	4.60	3.88	
34 to 39 months										
22	girl		34	1						
23	girl		34	8						
24	girl		34	14						
25	boy	125	35	3						1
26	boy		35	4						
27	boy		35	9						
28	boy	84	38	1						
29	boy		39	8						
30	boy		39	9						
31	boy		39	10						
					7	6.28	3	7.66	6.70	1

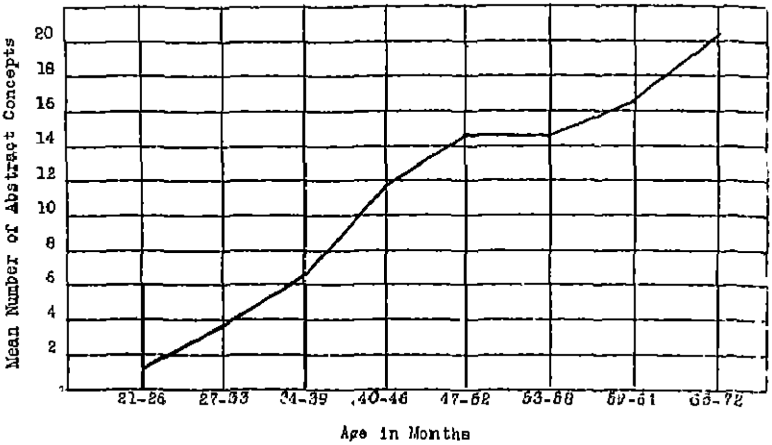


FIGURE I

c Between the ages of 21 and 46 months the girls seemed to have a slightly larger abstract vocabulary than the boys. After 46 months the boys seemed to have a larger vocabulary than the girls.

d The 12 institutional children of the Home for Hebrew Infants had an abstract vocabulary of a little over half the size of the 12 home children from 21 to 26 months of age. All of the institutional children were attending a Nursery school which is part of this institution. Still, their training, which began when they were about 21 months of age, was not sufficient to make up for linguistic training found in the normal home environment.

e We did not have enough subjects nor a sufficient number of ratings to make it worth while computing the correlation between abstract vocabulary development and general intelligence, still, from what data we have there is no suggestion of any high correlation

D CONDITIONING TESTS

1 *The Procedure*

a. The material In the "general" conditioning test eight unpainted wooden blocks of approximate size were used. Each was given an alphabetic name In order to establish first hierarchy concepts, the blocks were collected into four groups of two each and in turn, these groups were included in two more inclusive ones, which constituted second hierarchy concepts. The third hierarchy concepts involved the class which represented all of the blocks.

During the first few weeks of the experiment additional material was used which came under the category of a "special" conditioning test. This differed from the other in three respects—none of the objects were similar, all of them differed in color and the conditioning was carried out in the following manner: two repetitions of the genus symbol, two repetitions of the first species symbol, two repetitions of the second species symbol, two repetitions of the genus symbols, etc., until 10 repetitions had been given for each.

This test was abandoned after two of the three-year-old children

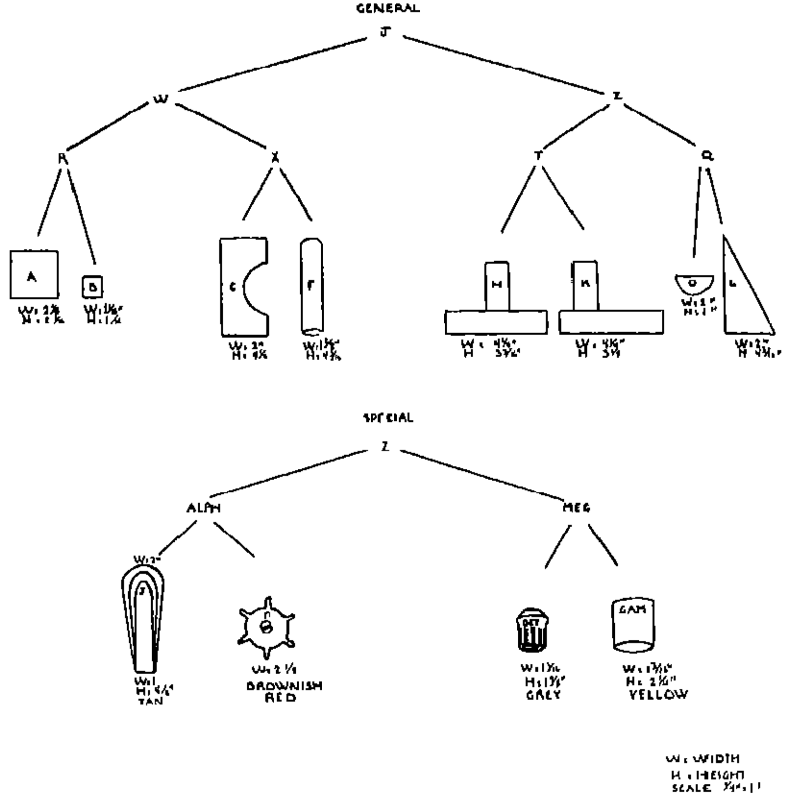


FIGURE 2
THE MATERIALS AND SYMBOLS FOR THE GENUS AND SPECIES TEST

had been tested, since we decided that the additional conditioning required was too tiring for the children.

A complete description of all of the materials and the symbols of both types of conditioning tests as they stood in their hierarchies will be found in Figure 2.

b *The conditioning.* All the repetitions of object names and class names were given in consecutive series of tens. Every effort was made to make the training periods appear like games As the object symbol was being repeated slowly, the block was moved about on a table in front of the child Often he repeated the word with the experimenter. When a class symbol was given, the child was told that the whole group was such and such a symbol He was told 10 times that on every occasion on which he was given this symbol he must pick up all of these blocks.

(1). *The techniques differed from test to test:*

(*a*) In Tests 1 and 2 the child was first given the species symbols and then the genus symbols In Tests 3 and 4, he was first given the genus symbols and then the species symbols. Tests 1 and 3 made use of blocks *similar in form*, and Tests 2 and 4 made use of blocks *dissimilar in form* We had hoped to discover whether a child grasped the class concept for *similar* objects sooner than the class concept for dissimilar concepts. In the second and third hierarchy tests the repetitions for the symbol of the most inclusive class were given last, if any other repetitions were necessary.

(*b*) If a child was given a second hierarchy test immediately after passing two of the first hierarchy tests (e.g., Test *A* or *B* immediately following Tests 1 and 2, or Tests 3 and 4), he was only given 10 repetitions of the symbol for the most inclusive class, which was the second hierarchy concept. If, however, an interval of a day or two came between the first hierarchy tests and the second hierarchy tests, he was given two trials for the correct identification of all of the concepts that he had been previously taught, to make certain he had not forgotten them. Those which he forgot were repeated 10 times each.

(*c*) The minimum number of repetitions of symbols that a child received for any concept was 10. The maximum was 50 Thus, if a child had but 10 repetitions for each of two symbols on one of the first hierarchy tests, but had received after repeated retesting, 50 repetitions on the third symbol, the test was then terminated.

c The nature of the tests themselves In all of the tests each symbol was given five trials irregularly. Hence, the total number of trials in a first hierarchy test was 15 and in the third hierarchy test (Test Alpha) 75. The identification of the blocks and their various classes were given to the child irregularly and the *criterion of success* in all of these tests allowed for but one failure. Thus, in any of the first hierarchy tests (Tests 1, 2, 3, 4) he was obliged to obtain a score of 93 per cent or more in order to be credited with having passed When he failed a test he was given 10 additional repetitions of each of the symbols which he had responded to incorrectly, until he reached a maximum of 50 repetitions for one of these There were a few exceptional cases where we gave 10 or 20 repetitions above 50—cases where the child had almost passed up to the point at which he had reached 50 repetitions on one or several symbols There was another exception The third hierarchy test (Test Alpha) took into account all of the repetitions of symbols that the child had received on the first and second hierarchy tests For instance, a child might have had 30 repetitions of the symbol *A* on Test 1 and 20 repetitions of the same on Test *A* before he was given the Alpha test Thus, he began Test Alpha with 50 repetitions of the symbol *A*. In cases of this sort, the child if unsuccessful was conditioned and retested four times

The procedure for the children from 36 to 42 months was slightly different from that used for the others. After the child had received his initial conditioning he was first required to identify each block separately in a group of non-block objects (small toys, dolls, balls, animals, etc.). Then he was required to identify the group of blocks (e g , pick up both) in a group of non-block objects. He was asked for the species or the genus five times irregularly in a total of 15 trials If the child passed these tests, then he was given a 10-trial test wherein he was obliged to discriminate one species from another. When he passed this he was given the final type of first hierarchy test of 15 trials, which involved both species and the genus These preliminary tests were designed for the purpose of discovering whether the child could distinguish the block symbols from ordinary symbols and to avoid in the beginning the confusion that might arise in the final three-concept test for the first hierarchy concepts

The preliminary tests involving the two species alone were given to all of the children below 66 months. In the case of children above 5½ years we began with the three-concept final test for 1st hierarchy knowledge immediately after the initial conditioning. In the case of the college students we skipped the first hierarchy tests completely and began with those for the second hierarchy. *After each trial in all of the tests the positions of the materials were changed.*

d. The subjects. Sixty-four subjects were used for the conditioning tests. Some of the children had been given the identification and questionnaire tests. In Table 4 subjects with *numerical* names are those who had been given the identification and questionnaire tests. The age range of the children was from 36 to 72 months. The college students were between 18 and 20 years of age. In Table 3 an account is given of the institutions to which these subjects belonged.

TABLE 3

Institutions	Age range in months	Boys	Girls	Total
The Normal Child Development Study of Columbia University	36-72	11	10	21
The Home for Hebrew Infants	36-44	2	8	10
The Manhattanville Day Nursery	43-63	8	1	9
The Hunter College Model School	64-72	5	5	10
Hunter College	18-20 Yrs	—	12	12
Bellevue Hospital*	14-18 Yrs	1	1	2
		27	37	64

*We wish to express our gratitude to Dr. Karl Bowman and the other members of the Psychiatric division of Bellevue Hospital for allowing us to give these tests.

e. Intelligence ratings. All that we have said concerning intelligence ratings in connection with the identification and questionnaire tests applies to these.

f. The test periods. We succeeded in giving the complete series of conditioning tests to the College students in span of from 20 to 25 minutes. The children from 72 to 42 months required a total average of one hour and a half, while the children from 36 to 42 months required a total average of from two to two-and-a-half hours.

The children from 72 to 48 months were never tested for more than three quarters of an hour at a time and the children below this age level were never tested more than 30 minutes at a time.

TABLE 4

Subject	Age	IQ	Intervals N	M span	Order	Mean repetitions Indiv	Group	Final scoring	% Passing
				Test 1 (1st Hierarchy)					
36 to 42 months									
SB	36	107	1	2	1	13 33		100*	
SL	36	92	1	2	2	20 00		100*	
AR	37	84	1	2	1	46 66		53	
GG	38	100	–	–	2	40.00		66	
RD	39	104	–	–	2	23 33		66	
JS	39	107	1	7	2	50.00		60	
ST	40	80	–	–	1	10 00		100*	
IN	42	85	1	2	2	40 00		33	
DN	42	91	1	2	2	20 00		93*	50
FD	42	79	–	–	2	10 00		100*	
							14 66		
43 to 49 months									
FR	44		1	2	1	50 00		100*	
38	44	113	–	–	2	10 00		100*	
41	46	102	–	–	2	10 00		100*	
42	46	109	–	–	2	13.33		100*	
47	48		–	–	2	16 33		100*	
46	48	90	–	–	2	50 00		33	
44	48	114	–	–	2	10.00		100*	
45	49	98	–	–	2	10 00		100*	87 50
							17 09		
50 to 56 months									
48	50	113	–	–	2	36 30		40	
51	51	126	–	–	2	10 00		100*	
49	51	100	–	–	2	30 00		100*	
50	51		–	–	2	10 00		100*	
52	53	124	–	–	2	10 00		100*	
56	55	107	–	–	2	10 00		100*	
LC	56	112	–	–	2	53 30		40	
61	56	111	–	–	2	20 00	15 00	100*	75
57 to 63 *months*									
59	57	102	–	–	2	43 33		33	
EH	58	133	–	–	2	36 33		100*	
LR	58	107	–	–	2	30 00		93*	
62	59	121	–	–	2	13 33		100*	
MD	61		–	–	2	13.33		100*	
CL	62	137	–	–	2	23 33		100*	
BB	62	134	–	–	2	10 00		100*	
66	62	98	–	–	2	23 33		100*	
67	62	104	–	–	2	33 33		100*	
68	62	96	–	–	2	10 00		100*	
71	63		–	–	2	10 00		100*	90 90
							20.29		

Test 2 (1st Hierarchy)

36 to 42 months									
SB	36	107	–	–	2	10.00		100*	
SL	36	92	4	2	1	50.00		96*	
AR	37	84	1	2	2	43.33		60	
GG	38	100	1	7	1	56.33		80	
RD	39	104	1	7	1	40.00		73	
JS	39	107	–	–	1	10.00		96*	
ST	40	80	1	2	2	23.33		100*	
FD	42	79	1	2	5	43.33		53	
IN	42	85	1	2	4	56.33		40	
DN	42	91	2	2	1	53.33		40	40
							23.33		
43 to 49 months									
FR	44		1	2	2	40.00		66	
38	44	113	–	–	1	43.33		66	
41	46	102	–	–	2	10.00		100*	
42	46	109	–	–	1	26.66		40	
47	48		–	–	1	10.00		100*	
46	48	90	–	–	1	50.00		20	
44	48	114	–	–	1	46.66		60	
45	49	98	–	–	1	10.00		100*	37.50
							10.00		
50 to 56 months									
48	50	113			2	43.33		33	
51	51	126			2	10.00		100*	
49	51				2	23.33		100*	
50	51				2	13.33		100*	
52	53	124			2	10.00		100*	
56	55	107			2	10.00		100*	
LC	56	112			2	40.00		20	
61	56	111			2	10.00		100*	75
							12.77		

TABLE 4 (*continued*)

Subject	Age	*IQ*	Intervals *N.*	*M* span	Order	Mean repetitions Indiv.	Group	Final scoring	% Passing
					Test 1 (continued)				
64 to 72 months									
FR	65	108			2	10.00		100*	
72	65	108			2	10.00		100*	
SH	65	*116*			2	10.00		100*	
74	67	100			2	10.00		100*	
76	68	107			2	10.00		100*	
75	68	109			2	10.00		100*	
73	68	121			2	10.00		100*	
78	69	116			2	10.00		100*	
79	69	109			2	10.00		100*	
80	71	116			2	10.00		100*	
81	72	115			2	13.33		100*	100
							10.30		

36 to 42 months									
SB	36	107	–	–	3	20 00		100*	
SL	36	92	1	2	4	23.33		96*	
AR	37	84	1	2	4	36 33		20	
WL	38	86	2	3	2	46 33		100*	
GG	38	100	–	–	3	26 33		20	
RD	39	104	1	7	3	73 33		33	
JS	39	107	1	7	4	56.33		40	
ST	40	80	1	2	4	30 00		100*	
RT	41	—	1	2	2	36 33		80	
FD	42	79	–	–	1	36 33		93*	
IN	42	85	1	2	3	46.33		33	45 45
							31 19		
43 to 49 months									
38	44	113	–	–	3	46 66		40	
42	46	—	–	–	3	43.33		40	
46	48	90	–	–	3	50.00		73	
44	48	114	–	–	3	46 66		20	0

TABLE 4 (*continued*)

Subject	Age	*IQ*	Intervals			Mean repetitions		Final	%
			N,	*M*. span	Order	Indiv	Group	scoring	Passing
					Test 2 (continued)				
57 to 63 months									
59	57	102			2	43 33		33	
EH	58	133			2	36 33		100*	
LR	58	107			2	30 00		93*	
62	59	121			2	13 33		100*	
MD	61				2	10 00		100*	
CL	62	137			2	20 00		100*	
BB	62	134			2	20 00		93*	
66	62	98			2	53 33		100*	
67	62	104			2	10 00		100*	
68	62	96			2	20.00		100*	
71	63				2	10 00		100*	90 90
							22 29		
64 to 72 months									
FR	65	108			2	10 00		100*	
72	65	108			2	10 00		100*	
SH	65	116			2	10 00		100*	
74	67	100			2	10 00		100*	
76	68	107			2	10.00		100*	
75	68	109			2	10.00		100*	
73	68	121			2	20 00		100*	
78	69	116			2	10 00		100*	
79	69	109			2	10 00		100*	
80	71	116			2	10 00		100*	
81	72	115			2	13 33		100*	100
							11 21		

Test 4 (1st Hierarchy)

36 to 42 months									
SB	36	107	–	–	4	10 00		96*	
AR	37	84	1	2	3	40 00		46	
WL	38	86	1	3	1	43 33		100*	
GG	38	100	–	–	4	26.33		60	
RD	39	104	1	7	4	63 33		26	
JS	39	107	1	7	3	63 33		40	
ST	40	80	–	–	3	10 00		100*	
RT	41	—	1	2	1	36 33		40	
FD	41	79	–	–	3	30 00		73	
IN	42	85	1	2	1	43 33		53	30
							21.11		
43 to 49 months									
38	44	113	–	–	4	10 00		100*	
42	46	09	–	–	4	16 66		100*	
46	48	90	–	–	4	50 00		73	
44	48	114	–	–	4	46.66		66	50
							13 33		
50 to 56 months									
48	50	113	–	–	4	40 00		60	
LC	56	112	–	–	4	50 00		53	0
57 to 63 months									
59	57	102	–	–	4	10 00		100*	

TABLE 4 (*continued*)

			Intervals			Mean repetitions		Final	%
Subject	Age	*IQ*	*N*	*M* span	Order	Indiv	Group	scoring	Passing
			Test 3 (1st Hierarchy)						
50 to 56 months									
48	50	113	—	—	3	36 33		40	
LC	56	112	—	—	3	50 00		13	0
57 to 63 months									
59	57	102	—	—	3	16 33		100*	
64 to 72 months									
FR	65	108			4	10 00		100*	
72	65	108			4	13 33		100*	
SH	65	116			4	10 00		100*	
74	67	100			4	10 00		100*	
76	68	107			4	10.00		100*	
75	68	109			4	10 00		100*	
79	69	109			4	36 33		93*	
80	71	116			4	13 33		100*	100
81	72	115							
							14.12		

Subject	Age	*IQ*	Intervals		Structural defect	Order	Mean repetitions		Final scoring	% Passing
			N	*M* span			Indiv	Group		
					Test A (2nd Hierarchy)					
36 to 42 months										
FD	42	79	1	2	*G*	4	50 00		20	
43 to 49 months										
41	46	102	1	2	*PT*	3	43 00		57	
47	48	—	1	2	*G*	–	50 00		28	
45	48	98	1	2	*MP*	3	28,50		57	0
50 to 56 months										
49	51	—	–	–	*G*	3	47 14		37	
51	51	126	1	2	*G*	3	41 42		45	
52	53	124	1	2	*PT*	3	28 57		68	
56	55	107	1	2	*G*	3	50 00		22	
61	56	112	–	–	*G*	3	37 57		51	0
57 to 63 months										
EH	58	133	1	2	*G*	3	44 28		14	
LR	58	107	1	2	*G*	3	51 42		25	
62	59	121	1	2	*G*	3	45 71		27	
MD	61	—	1	2	*G*	3	48 57		14	
CL	62	137	1	2	*G*	3	52 85		37	
BB	62	134	1	2	*MP*	3	32 85		80	
66	62	98	1	2	*G*	3	74 28		34	
67	62	104	1	2	*G*	3	60 00		11	
68	62	96	1	2	*G*	3	52 85		74	0
71	63	—	1	2	*G*	3	47 14		34	0

TABLE 4 (*continued*)

Subject	Age	*IQ*	Intervals *N*	Intervals *M* span	Order	Mean repetitions Indiv.	Mean repetitions Group	Final scoring	% Passing
64 to 72 months									
FR	65	108			5	10.00		100*	
72	65	108			5	10.00		100*	
SH	65	116			5	10.00		100*	
74	67	100			5	10.00		100*	
76	68	107			5	10.00		100*	
75	68	109			5	10.00		100*	
79	69	109			5	13.33		100*	
80	71	116			5	10.00		100*	
81	72	115			5	10.00		100*	100
							10.37		

Special First Hierarchy Test

Subject	Age	*IQ*	Intervals *N*	Intervals *M* span	Structural Defect (*a*)	Mean repetitions *Indiv*	Mean repetitions *Group*	Final scoring	% Passing
SB	36	107	4	2	*MP*	50.00		71	
ST	40	80	3	2	*MP*	58.57		71	0

NOTE (*a*) See Paragraph 3 in the discussion of the results and Figure 3 for a description of this term

Test A (continued)

College Juniors										
	Yrs									
RL	18	—				1	10 00		100*	
LC	18	140				2	10.00		100*	
LW	18	—				2	10.00		100*	
HW	19	165			*G*	1	24.28		100*	
DF	19	128				1	10.00		100*	
EE	19	—				2	10 00		100*	
MH	19	126				2	10.00		100*	
AM	19	125				1	10 00		100*	
AB	20	—				1	10 00		100*	
HK	20	—				2	10 00		100*	
Os	20	120				1	10.00		100*	
LL	20	116				2	10 00		100*	100
								11 19		

Test B (2nd Hierarchy)

57 to 63 months										
59	57	102	–	–	*G*	3	45 71		34	
64 to 72 months										
72	65	108			*MP*	6	14 28		100*	
GR	65	108			*MP*	6	24 28		80	
SH	65	116			—	6	10 00		100*	
74	67	100			*MP*	6	12.85		100*	
76	68	107			—	6	10 00		100*	
75	68	109			—	6	10 00		100*	
78	69	116			—	6	10 00		100*	
79	69	109			—	6	10 00		100*	
80	71	116			*MP*	6	22 85		100*	
81	72	115			*G*	6	15 71		100*	90
								12 85		

TABLE 4 (*continued*)

Subject	Age	*IQ*	Intervals *N*	*M.* span	Structural defect	Order	Mean repetitions Indiv	Mean repetitions Group	Final scoring	% Passing
64 to 72 months										
FR	65	108	–	–	—	3	10.00		100*	
72	65	108	1	2	*G*	3	35.71		91*	
SH	65	116	–	–	*MP*	3	10.00		100*	
74	67	100	–	–	*MP*	3	10.00		100*	
76	68	107	–	–	—	3	10.00		100*	
75	68	109	–	–	—	3	10.00		100*	
73	68	121	–	–	—	3	45.71		88	
78	69	116	–	–	*PT*	3	14.28		100*	
79	69	109	1	2	*PT*	3	13.00		100*	
80	71	116	–	–	—	3	10.00		100*	
81	72	115	–	–	—	3	10.00	13.29	100*	90.90

Subnormal Group

Test Alpha (3rd Hierarchy)

64 to 72 months										
72	65	108	1	1	*MP*	3	14 00		100*	
GR	—	—	–	–	—	–	——		——	
SH	65	116	1	7	—	3	10 66		100*	
74	67	100	–	–	*MP*	3	14.66		100*	
76	68	107	1	2	—	3	10.66		100*	
75	68	109	1	7	*MP*	3	18 66		100*	
73	—	—	–	–	—	–	——		——	
78	69	116	1	2	*MP*	3	28 00		96*	
79	—	—	–	–	—	–	——		——	
80	71	116	1	2	*MP*	3	20 00		100*	
81	72	115	2	2	*PT*	3	34 00		62	87 50
								16.66		
College Juniors										
	Yrs									
RL	18	—				3	10 00		100*	
LC	18	140				3	11 00		100*	
LW	18	—				3	10 00		100*	
HW	19	165				3	16 00		100*	
DF	19	128				3	12 40		100*	
EE	19	—				3	10 00		100*	
MH	19	126				3	10 00		100*	
AM	19	125				3	10 00		100*	
AB	20	—				3	10 00		100*	
HK	20	—				3	10 00		100*	
DS	20	120			*MP*	3	12 00		100*	
LL	20	116				3	10 00		100*	100
								10 95		

Test 4 (continued)

Subject	Age	IQ	Intervals		Structural defect	Order	Mean repetitions		Final scoring	% Passing
			N	M span			Indiv	Group		
College Juniors										
	Yrs									
RL	18	—			—	2	10.00		100*	
LC	18	140			—	1	10.00		100*	
LW	18	—			*MP*	1	12.85		100*	
HW	19	165			—	2	10.00		100*	
DF	19	128			*G*	2	15.71		100*	
EE	19	—				1	10.00		100*	
MH	19	126				1	10.00		100*	
AM	19	125				2	10.00		100*	
AB	20	—				2	10.00		100*	
HK	20	—				1	10.00		100*	
DS	20	120				2	10.00		100*	
LL	20	116				1	10.00		100*	100
								10.71		

We endeavored to keep a standard interval of two days between the test periods given to any one subject, but in many cases circumstances made this impossible In the *"Interval Column"* of Table 4 *"N"* = the number of intervals that occurred during one test and *"M Span"* = the average number of days that these intervals constituted. We regret that there should have been any variable of time, but this was quite unavoidable. In several cases where a child had a 7-day interval we gave the child from 20 to 30 additional repetitions of the word It is hard to say how important this time factor is. Many of the children from 36 to 72 months who had passed certain tests remembered the concepts that these involved for as long a period as seven and even 10 days. We did not dare to shorten intervals much below two days, since this was likely to decrease the child's interest in the test.

g. Motivation and rewards. It is very difficult to maintain interest in any type of test for children that involves language and particularly in tests that require linguistic conditioning. On the whole, our children coöperated well. Every effort was made to make these tests assume the character of a game. Some children were amused by throwing the objects which they identified about the room, others by pretending that they were selecting the right object for a toy soldier who was being tested. The test materials were often danced in front of the children during the conditioning period, placed on their laps, held up against the wall, placed on the floor, etc.

In the beginning we offered the child rewards, such as candy or toys, but these seemed to have little effect. If he did not receive the rewards within three or four minutes he seemed to lose all hope or interest in them If he was given the rewards within this period, he was satisfied and did not show much interest in receiving any others.

The child was praised for any choice he made during the test, whether it was right or wrong. Otherwise, he would have been guided to choose correctly by virtue of the reprovals he received after making an incorrect choice.

h. Differences in the personalities of the experimenters. These tests were given by two experimenters. One was quite calm but firm in dealing with the children, the other endeavored to create a state of excitement by chatting a great deal and by encouraging the children to act quickly in selecting the blocks during the tests.

For two months both experimenters conditioned and tested the same children during the same tests. They alternated about every five minutes during conditioning periods and tests. One time one would succeed when the other failed in interesting the child, and on another occasion the same child would respond better to the experimenter who previously had not been quite so successful with him. It was impossible to state qualitatively or quantitatively during this period that one experimenter was continually more effective than the other, even when the scope of the inquiry was limited to an individual case.

t The method of presenting data in Table 4.

(1). The scores for any individual concept in all of the conditioning tests requires a table of about 75 pages We therefore condensed these scores to a series of averages. In the *"Individual"* column under *"Mean Repetitions"* we have given the averages of each subject on each test In the *"Group"* column we have given the mean average of *those subjects only who passed the test.*

(2) The asterisk indicates the scores of those who passed

(3) In the *"order"* column we have shown the sequence of each test in the series as given to any one subject

(4). The intervals which occurred in any one test are given, but not the intervals as they occurred in between the tests themselves (e.g , the intervals between Tests *A*, *B* and *Alpha*). These closely approximated an average of two days

2. *The Results*

a. A comparison of hierarchical learning. Table 5 summarizes the records of comparative learning found in Table 4.

TABLE 5
THE PERCENTAGE PASSING AT LEAST ONE TEST FOR EACH HIERARCHY

Ages	*N*	1st	2nd	3rd
36-42 months	12	58 33	——	——
43-49 months	8	87 50	——	——
50-56 months	8	75 00	——	——
57-63 months	11	100,00	——	——
64-72 months	11	100 00	90,9	63 63
18-20 years	12	100 00	100 00	100 00

(1) The improvement in learning was quite gradual between the ages of 36 and 57 months A spurt in learning occurred in many

cases at the approach of the 6th year age level. This spurt is similar to the increase in abstract vocabulary at the same period of development which we discussed in connection with the identification and questionnaire tests.

(2). Two mental defectives, one a girl 18 years old with an *IQ* of 57, and the other a boy 14 years old with an *IQ* of 63, passed the second and third hierarchy tests The details of these tests are not given here as this material is to be used later in a separate study of the hierarchical development of normal, amented, and demented subjects at the adolescent and adult levels. These results together with those of the college students affords no justifiable grounds for a comparison of the childhood and adult processes of abstract thinking; still, we do feel that the fact that two mental defectives passed these tests is worth mentioning. It suggests that the memory requirements in our tests were within the normal limits of early childhood.

(3). We endeavored to give all of the children from 36 to 42 months the four first hierarchy tests. None of the children beyond this age level were given more than two first hierarchy tests if they failed their first second hierarchy test. Still, some of the children from 36 to 42 months, for various reasons, were only given two first hierarchy tests In Table 6 these data are presented alone.

TABLE 6

RESULTS OF TESTS 1, 2, 3, 4 GIVEN TO CHILDREN 36 TO 42 MONTHS

Subjects	Test 1	Test 2	Test 3	Test 4
SB	Passed	Passed	Passed	Passed
SL	Passed	Passed	Passed	——
AR	Failed	Failed	Failed	Failed
WL	——	——	Passed	Passed
GG	Failed	Failed	Failed	Failed
RD	Failed	Failed	Failed	Failed
JS	*Failed*	*Passed*	*Failed*	*Failed*
ST	Passed	Passed	Passed	Passed
RT	——	——	Failed	Failed
IN	Failed	Failed	Failed	Failed
FD	Passed	Failed	Passed	Failed
DN	Passed	Failed	——	——

Of the children recorded in Table 6 58.33 per cent passed at least one first hierarchy test, 33.33 per cent passed all of the tests given to them, while 41.66 per cent failed all of the tests given to them. There were only three cases of a child passing some of these tests and failing others *b Differences in the order of tests and materials* The only group with which we had ample opportunity to examine the effects of different orders of testing was the group from 36 to 42 months of age. Unfortunately, it was not large enough to be given any valid scientific basis for conclusions. Hence, these data can only be of value when we add to them more at a later date Table 7 summarizes the order of all the first hierarchy tests given to the youngest group

TABLE 7

NUMBER OF CHILDREN

Test	1st order	2nd order	3rd order	4th order
1	3	7	–	–
2	5	3	–	1
3	1	2	4	4
4	3	–	4	3
Totals	12	12	8	8

The order for the groups of older children were standardized to the following—Test 2, Test 1, Test *A*, Test 3, Test 4, Test *B*, Test Alpha. Half of the college students were given the order—Test *A*, Test *B*, Test Alpha, and half were given the order Test *B*, Test *A*, Test Alpha. There was always the possibility that any first test a subject was given might be the hardest and that after he "caught on," so to speak, the next test might be easier. Hence, half of the college group began with the tests which required the subjects to be first conditioned to the species symbols and last to the genus symbols, while the other half began with the tests which required the subjects to be first conditioned to the genus symbols and last to the species symbols. The results of these two series were the same and suggested no differences from the standpoint of the type of symbol first taught or of the similarity or dissimilarity of the material itself.

None of these data are sufficient in number to scientifically prove whether a subject learns abstract concepts quicker if first conditioned to species symbols and afterwards to genus symbols or visa versa, or whether he learns class symbols quicker with similar material than with dissimilar material The records of our children show some *slight* differences, but we are calling attention to these only as a matter of routine, since they may be of future value if they correlate with results of similar experiments Such data are presented in Table 8.

TABLE 8

Children from 36 to 42 months of age

Test 1		*Test 2*	
Species Given 1st with Similars		*Species given 1st with Dissimilars*	
Percentage passing	N. of repetitions for the group	Percentage passing	N of repetitions for the group
50	14 66	40	23 33
Test 3		*Test 4*	
Genus given 1st with Similars		*Genus given 1st with Dissimilars*	
Percentage passing	N. of repetitions for the group	Percentage passing	N of repetitions for the group
45.45	31 19	30	21 11

The average of the percentages passing and group conditioning of the children from 36 to 42 months

Results of Tests 1 and 2 Averaged		*Results of Tests 3 and 4 Averaged*	
Species given 1st		*Genus given 1st*	
Percentage passing	Group conditioning	Percentage passing	Group conditioning
45	18.99	37.72	26 15
Results of Tests 1 and 3 Averaged		*Results of Tests 2 and 4 Averaged*	
Similar Materials		*Dissimilar Materials*	
Percentage passing	Group conditioning	Percentage passing	Group conditioning
47 72	22 92	35	22 22

The percentage of subjects passing Tests 1, 2, 3 and 4 in all of the groups

Groups	Test 1	Test 2	Test 3	Test 4
36-42 months	50	40	45 45	30
43-49 months	87 50	37.50	—	50
50-56 months	75	75	—	—
57-63 months	90 90	90.90	100	100
64-72 months	100	100	100	100

The symbol "—" means that either no tests were given or there was too small a number of them.

If we are to take any account of the slight differences found in Table 8, it would seem that *on a basis of the percentage passing* the order of the tests easiest to learn was:

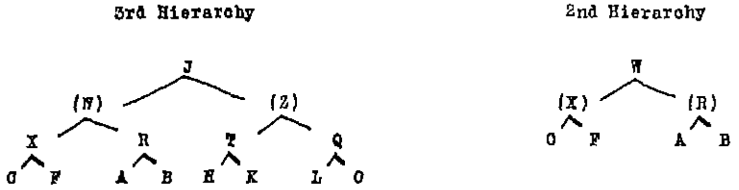
Species 1st with similars	(Test 1)
Genus 1st with similars	(Test 2)
Species 1st with dissimilars	(Test 3)
Genus 1st with dissimilars	(Test 4)

On the other hand, *on a basis of the smallest number of repetitions needed* the order seemed to be:

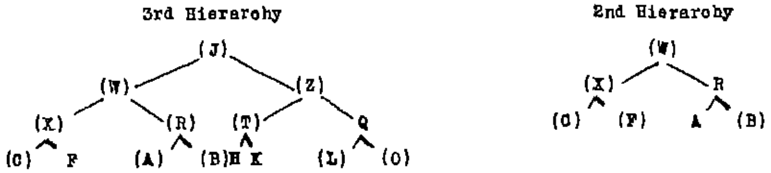
Species 1st with similars	(Test 1)
Genus 1st with dissimilars	(Test 4)
Species 1st with dissimilars	(Test 2)
Genus 1st with similars	(Test 3)

If there is any conclusion to draw from these data at all it is only the hypothetical statement that "It *seems* as though there were no marked differences brought about in the learning process, in virtue of the species being taught first or of the material being similar"

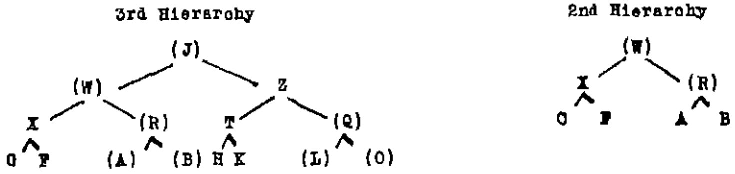
c. Weaknesses in structural development. The failures of those



Mid-point Failures



General Confusion



Partial Confusion.

Note - the symbol "( )" indicates that the child did not grasp or forgot that concept.

FIGURE 3

who never learned and those who eventually learned second and third hierarchy concepts, may be divided into three categories: *Midpoint failures, General confusion,* and *Partial confusion.* The diagrams in Figure 3 are examples of all three types. The *Midpoint failures* may be understood as a telescoping of a third hierarchical structure down to the second level, or the telescoping of a second hierarchical structure down to the first level Cases of *General confusion* seem to indicate that the process of teaching some of the children higher level concepts after they had learned the lower level concepts confused what they had been taught already. Cases of *Partial confusion* seemed to indicate that the children retained something of what they had previously learned, but did not grasp or remember the additional data required in the higher tests

Table 9 shows the frequency of these different types of failure.

TABLE 9

WEAKNESSES IN STRUCTURAL DEVELOPMENT FOR ALL OF THE SUBJECTS WHO TOOK THE SECOND AND THIRD HIERARCHY TESTS

Total failures examined = 42

Tests	Midpoint	General	Partial
2nd Hierarchy			
*A**	6	17	4
B	5	3	0
3rd Hierarchy			
Alpha	6	0	1
	17	20	5

*The 1st hierarchy "Special tests" are included under Test *A*.

d The conditioning need for various age levels It is impossible to make a detailed analysis of this phase of the study with the crude data that we have collected. So many variables enter into the situation that the facts themselves are probably misleading There seems to be a marked difference in these tests between the number of repetitions required for the 57-64-month group and the 65-72-month group. All of these data are presented in Table 10 together with the percentages passing tests in each group.

e. None of the subjects between 36 and 42 months were institutional children. The others with *IQ*'s above 100 were home children. All of the latter at this age level showed the poorest results on the first hierarchy tests With so few cases we can hope for

TABLE 10

Groups	Test 1 % Passing	 M. Conds	Test 2 % Passing	 M Conds
36-42 months	50	14.66	40	23.33
43-49 months	87.50	17.09	37.50	10.00
50-56 months	75	15	75	12.77
57-63 months	90.90	20.29	90.90	22.29
64-72 months	100	10.30	100	11.21

Test *A*		Test *B*	
% Passing	*M* Conds	% Passing	*M.* Conds
0		0	
0		0	
0		0	
0		0	
90.90	13 29	90	12 85

no scientifically valid conclusion, but there is a *suggestion* that though institutional children through lack of training do poorly on any vocabulary test, they may have potentialities for linguistic learning equal to the home child. This hypothesis is in strict agreement with numerous cases that have been observed by officers of the Home for Hebrew Infants, who have studied the children of the institution after they had been placed in foster homes.

We omitted several of the tests from Table 9 because they did not afford enough data.

E THE SUMMARY

1 *The Problem*

The purpose of this study was to discover when children normally begin to learn abstract concepts—to ascertain the rate at which their vocabulary of abstract concepts normally increases, to determine how much training is necessary in order to teach children from three to six years of age abstract concepts of the first, second and third order and to make an analysis of the general development of the hierarchical structures supporting the second and third hierarchy concepts

Two different types of tests were used: One was an identification and questionnaire test given to 93 children from 21 to 72 months of age, the other involved teaching subjects alphabetic names for eight geometric blocks and the symbols representing the groups into which the blocks were arranged These groups constituted first, second, and third order concepts. The conditioning tests were given to 64 subjects—50 children from 36 to 72 months of age, 12 college women from 18 to 20 years of age, and two mental defectives, one 14 and the other 18 years of age

2. *General Comments*

1 On the identification and questionnaire tests, the children from 21 to 26 months manifested a knowledge of a group average of 1 16 abstract concepts. Institutional children from 34 to 44 months of age had a group average of only .91 abstract concepts, while those between 5½ and 6 years had a group average of 20.60 On the conditioning tests for abstract learning, the institutional children did better than the others, suggesting that this type of child has at least normal potentialities for such learning.

2 The greatest gain in abstract vocabulary seemed to be between the 34-39-month level and the 40-46-month level The gain between the 59-64-month level and the 65-72-month level was almost as high. Between the 47-52-month level and the 53-58-month level there was a fractional decline

3. Four out of 21 children between 34 and 46 months of age and 18 out of 29 between 47 and 64 months of age manifested knowledge of at least one second hierarchy concept Only two children below 5½ years showed a knowledge of two second hierarchy concepts, while all of the 10 children over 5½ years understood two, and four of them understood three second hierarchy concepts

4. Between the ages of 21 and 46 months the girls seemed to have a slightly larger vocabulary than the boys After 46 months the boys seemed to have a larger vocabulary than the girls.

5 In the block conditioning tests the improvement in learning was quite gradual between the ages of 36 and 57 months A spurt in learning occurred in many cases at the approach of the 6th year age level This spurt correlates with the increase in abstract vocabulary at the same period, as was shown in connection with the identification and questionnaire tests

6. Weaknesses in structural development were divided into three categories—midpoint failures, general confusion and partial confusion The most common was general confusion (20 out of 42 cases) and the next in order was midpoint failure (17 out of 42).

7 There was an indication that the older children needed less conditioning in the block tests than the younger children

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SHORT ARTICLES AND NOTES

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HIGH SCHOOL NORMS FOR THE MIRROR-DRAWING TEST OF THE SIX-POINTED STAR*

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Since 1905, when Dearborn first made use of the mirror-drawing of the six-pointed star in the experimental laboratory, the test has been many times described and its use often expounded Starch wrote that the test had several commendable uses; that it could be employed as a laboratory exercise; that it could be used to investigate problems in the psychology of learning, and to study the transference of training. Lehman and Witty, years later, in describing a *Convenient Mirror-drawing Device,* stated that "mirror-drawing simply and clearly demonstrates certain essential elements in habituation and learning."

The mirror-drawing of the six-pointed star has been employed to gain some insight into the personality of individuals Holsopple administered the test to thousands of inmates of jails and reformatories to gain a knowledge of their emotional stability and reactive behavior. He used the six-pointed star test together with various other applicable tests to determine the advisability of parole for the criminals Further study is needed in this field to discover the values of the test in personality diagnosis

The test was administered by Stone to students of the Samuel J. Tilden High School in Brooklyn, New York, who came to him for counseling or were recommended by other school officials. It was observed that students who were nervous, who bit their nails, did poorly on the tests. Good students usually had difficulty with the first trial but improved greatly on the succeeding trials

To make a more accurate determination of the meaning of the

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high school students' test results, norms were needed. From these norms, quantitative descriptions could be immediately made of an individual's deviation from the average.

The sampling population to establish high school norms consisted of 78 females and 115 males. The students tested were of the usual high school ages, 13 to 17, of both sexes and ranged from the first to the eighth grades. There was no time interval between the six trials of the mirror-drawing test, each trial being given one after the other. The Otis *Self-Administering Test, Higher Form B,* also was given to each of the students. The mean intelligence quotient (Otis test) was 92.7 with a standard deviation of 11.1 for the males, and 90.1 with a standard deviation of 12.5 for the females.

Norms were calculated in terms of medians, interquartile ranges, and means for each trial and for the average of the six trials for each sex. The norms are given in Table 1.

TABLE 1

NORMS FOR HIGH SCHOOL STUDENTS ON THE MIRROR-DRAWING TEST OF THE SIX-POINTED STAR

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Average
			Girls				
Median	245.0	150.0	117.5	91.0	68.3	60.7	143.8
Interquartile Range (Q)	163.0	123.5	100.8	38.5	29.9	24.2	43.2
average	328.5	186.9	124.5	106.5	83.2	72.1	148.8
			Boys				
Median	225.0	158.6	108.0	88.1	64.0	57.3	128.3
Interquartile Range (Q)	106.7	56.4	37.3	33.3	22.2	17.2	44.3
average	303.8	175.8	118.5	95.2	72.5	63.7	138.4

It is immediately evident that the boys did slightly better than the girls on each trial. This is at variance with the findings of other studies. Whipple writes "that girls decidedly surpass boys and that women decidedly surpass men is shown in all the published studies in mirror-drawing with the exception of two groups reported by Burt and Moore, and in them certain divergencies in method and in other test conditions offer a sufficient explanation of the apparent exception" (5). He goes on to say that "it is not only possible, but probable, that this sex-difference is in some part due to greater familiarity of women with the use of the mirror."

Whipple considered the Yoakum and Calfee norms for the patterns as the best. The median in seconds of the average of the six trials was 110.33 for the elementary school boys, 97.83 for the male college freshmen, and 54.70 for the female freshmen. These norms were calculated from three groups, the first comprising 30 elementary school boys, the second 52 women in the freshman class of the University of Texas, and the third 51 men in the freshman class. There is no group consisting of elementary school girls. It would have been interesting to note whether or not there was a significant sex difference between the elementary school girls and boys. The use of the mirror may not yet, at that age, have given much opportunity for practice.

To ascertain the degree of relationship between the speed on the sixth trial and the intelligence quotient, and also between the speed on the average of the six trials and the intelligence quotient, Pearson product-moment correlations were calculated for each sex. For the females, the correlation coefficient of the speed on the sixth trial and intelligence quotient was +.135±.075, and for the speed on the average of the six trials and intelligence quotient, +.103±.076. For the males, the correlation coefficient of the speed on the sixth trial and intelligence quotient was +.093±.062, and for the speed on the average of the six trials and intelligence quotient +.132±.062. It can be stated that there is very little relationship between speed on the mirror-drawing test and intelligence for the groups used in this study.

These correlational results agree with Miss Calfee's, which found that the mirror-test correlated +.07 with the grades of the elementary school group, —.07 with the grades of the male college students, and +.19 with the grades of the female college students.

CONCLUSIONS

The norms on the mirror-drawing test of the six-pointed star for the high school group can be used to obtain a profile of a student's deviations from the median for each trial and for the average of the six trials. The profile thus obtained will afford a picture of the student's course of learning and his adjustability to a new situation.

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THE RELATIVE VARIABILITY IN INTELLIGENCE OF BOYS AND GIRLS*

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The view which prevailed some years ago that males are more variable than females rested on two different lines of evidence. The first was a sociological observation that famous men outnumber famous women and that there are more males than females in homes for the feebleminded. The other line of evidence came from various mental and physical measurements.

The first of these arguments possesses little scientific value. Men have been under the necessity of making careers for themselves and have consequently had greater opportunities for achievement. Feebleminded girls are shielded at home to a larger extent than feebleminded boys. The girls who are in institutions for the feebleminded are usually more stupid than the boys, since only the worst cases of the girls are committed.[1]

The evidence from mental and physical measurements is conflicting. Whether girls or boys are more variable seems in some cases to depend upon which measure of variability is used (2).

In all such studies it is not only the direction but also the reliability of the difference which must be determined. And since it is easier to secure a reliable difference for large groups than for small ones, the following data (Table 1) would seem to offer a desirable basis for computations. The figures represent *IQ*'s made on the National Intelligence Test by 10,079 children in Grades 3 to 8 of 22 city schools.

TABLE 1

	N	Mean	*Q*	*MD*	*V*	σ
Boys	5069	103.56	12.22	14.40	17.39	18.004
Girls	5010	106.94	11.92	14.25	16.86	18.028

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[1] Similar evidence has been presented by the writer to the effect that the 174 boys in the ungraded rooms of a city school system had a median *IQ* of 80.9, while for the 73 girls the median was 78.6 (1).

The girls are ahead of the boys, and by a reliable difference, since

$$\frac{M_2 - M_1}{\sigma_{M_2 - M_1}} = 9.42$$

On the basis of Q, MD, and V, the boys seem the more variable, but the girls have the larger σ.

The reliability of the difference between the Q's was determined by the following method:

$$Q_1 - Q_2 = .30$$

$$\sigma_{Q_1 - Q_2} = \sqrt{\frac{(1.65Q_1)^2}{2N_1} + \frac{(1.65Q_2)^2}{2N_2}} = .28$$

$$\frac{.30}{.28} = 1.07$$

The difference is not reliable.

The corresponding computations with regard to the difference between the MD's is:

$$MD_1 - MD_2 = .15$$

$$\sigma_{MD_1 - MD_2} = \sqrt{\frac{(.7555MD_1)^2}{N_1} + \frac{(.7555MD_2)^2}{N_2}} = .216$$

$$\frac{15}{216} = .69$$

The difference is not reliable.

The corresponding computations with regard to the difference between the V's is:

$$V_1 - V_2 = .53$$

$$\sigma_{V_1 - V_2} = \sqrt{\frac{V_1^2}{2N_1} + \frac{V_2^2}{2N_2}} = .24$$

$$\frac{.53}{24} = 2.21$$

This comes the closest to being a reliable difference. The formula used for computing the V's was

$$V = \frac{100\sigma}{M}$$

and the size of V_2 is reduced considerably by the large value for M_2 in the case of the girls.

The corresponding computations with regard to the difference between the σ's is:

$$\sigma_2 - \sigma_1 = .024$$

$$\sigma_{\sigma_2 - \sigma_1} = \sqrt{\frac{{\sigma_2}^2}{2N_2} + \frac{{\sigma_1}^2}{2N_1}} = 254$$

Since the difference is less than one-tenth of its own sigma, this, the only difference showing a greater variability for the girls, is the least reliable of all.

But perhaps the boys predominate at the extreme ends of the distribution. To check this possibility the upper 7 per cent and the lower 7 per cent of the total group of boys and girls were taken. There were theoretically 303.4 boys and 402.3 girls in the upper 7 per cent of the total distribution. There were 420.1 boys and 285.6 girls in the lower 7 per cent of the total distribution. If both of the extreme groups are now combined, we find that there are 723.5 boys and 687.9 girls. These 723.5 boys represent .1427 of the total number of 5,069 boys, while the 687.9 girls represent .1373 of the 5,010 girls. The reliability of the difference between these proportions was determined by the following method:

$$P_1 - P_2 = .0054$$

$$\sigma_{P_1 - P_2} = \sqrt{\frac{P_1 q_1}{N_1} + \frac{P_2 q_2}{N_2}} = .0069$$

$$\frac{.0054}{.0069} = .78$$

This difference also is unreliable.

SUMMARY

The relative variability of 5,069 boys and 5,010 girls, based upon *IQ*'s made on the *National Intelligence Test,* was computed in five ways, by means of *Q*, *MD*, *V*, σ, and the proportions of boys and girls in the upper and lower 7 per cent of the total group. Each measure except the σ showed the boys to be slightly the more variable. None of the differences found were reliable, although the difference in the case of the coefficients of variability approached reliability. In general the evidence supports the view that there is no appreciable sex difference in variability.

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NOTE ON THE JOEL SCALE OF "BEHAVIOR MATURITY"*

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In 1936 appeared a paper (1) by Joel dealing with a scale which he devised, designed to measure "behavior maturity," or, "grown-up-ness" in young children. It consisted of 20 items concerning child behavior in the nursery school situation, the rater checked for each item one type of response characteristic for the child in question. On the basis of biserial correlation of each item with chronological age, Joel calculated regression weights, and scored the children on the basis of these weights. Finding that his final scoring weights yielded indices which correlated .65 with chronological age, Joel concluded that for a five-point rating scale, this criterion indicated that the test was a good measure of behavior maturity. His final contribution was to calculate age values for the weighted scores, so that it was possible thereby to obtain ratios of chronological to behavior age—that is, for each child a Behavior Maturity Index.

I thought it might be interesting briefly to present some results of the use of the Joel Scale with a group of 73 children over a period of two years. The children observed were rated from one to five times; the average number of ratings was 2.7. The children were either members of the Antioch Nursery School group or of the Fels group of children who are being studied serially. All of the children were rated after at least one month's observation in the nursery school, and, excepting in five instances, all of the 112 ratings were either joint ratings by at least two and usually three teachers in conference, or independent simultaneous ratings by two teachers which could later be averaged.

Before much attention was directed to the data yielded by our group, the Joel standardization material itself was examined in detail. From Joel's material, it is clear that certain items, on the basis of the reported mean age values for various ratings on them

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(and regression weights) possessed more "maturity value" than others. This the author indicated in his summary. He put the case mildly, however, for it is found that the age differentiation (or differences in mean age between the highest and lowest ratings on each scale) is less than six months for six items (6, 7, 12, 13, 14, and 17), between six months and one year for seven more (1, 2, 8, 10, 11, 15, and 18), leaving but seven items with discrimination for the age criterion of one year or greater. It seemed to us logical that if chronological age were to be the criterion it would be entirely valid (if not more valid, since it might "purify" the measure) to score the child for "Behavior Maturity" only on the items showing age discrimination, rather than on the total number of 20 items.

Following this line of thought we scored our group of 48 children on the basis of the items shown in Table 1.

TABLE 1

Item number	Designation	Joel age discrimination value (in months)
3	Toilet	18.5
4	Removing wraps	16.7
5	Washing	18.6
9	Persistence	12.8
16	Sociability	20.6
18	Taking turns	10.6
19	Reaction to others	12.5
20	Leadership	17.9

It seemed likely that the score for these eight items should correlate as well with chronological age as would the score for all 20 items, since these eight represented those items which had the best age discriminations. The coefficients obtained for 73 ratings were as follows:

Long scores with short score	.972
Long score with age	.777
Short score with age	.807

It is seen, therefore, that the short form correlates slightly better with chronological age than does the long form. According to Joel's criterion of maturity, then, the short scale is slightly better than the long scale of 20 items. That the short form measures practically everything but a little additional chronological age is evidenced by the coefficient of intercorrelation of the two forms, .972.

All Joel scores used in further calculations were, after this finding, calculated on the basis of the eight items mentioned above (Before passing, however, it is interesting to note that even the long form scores obtained by us correlated with chronological age to a greater degree than did Joel's scores for his preliminary and final groups .72, 71, and .65)

For 42 of our children mental tests were administered so that they distributed evenly over the period during which the Joel ratings were made These mental tests were the *Merrill-Palmer Scale* and the *Stanford-Binet* Mean *IQ*'s were obtained for each child on the basis of two to seven tests, with an average number of 3 4. Behavior indices were calculated according to the method suggested by Joel, using his 20-item age norms equated for our eight items. This equating was done using the regression of the long form score on the short form (r = .972) A coefficient of 394 was obtained between mean *IQ* and mean *Behavior Index,* indicating small degree of relationship This coefficient is considerably higher that that obtained by Joel between the *Behavior Maturity Index* and *IQ* as measured by the *California Preschool Mental Scale* (036). Why this is we can't say, since the samplings in *IQ* as well as in *Behavior Index* seem comparable

Joel reports nothing concerning the reliability of his scale, and our own evidence is meagre Duplicate ratings on 10 children (made independently by two observers) correlated by the method of rank differences 76, and with age partialled out, 65 This is not particularly high, and is good evidence for Joel's suggestion that ratings be made as pooled judgments, or even better still, after conference among teachers. The fact that the correlation of the pooled judgment scores with chronological age is greater than the intercorrelation between independent judges would act as further evidence for the increased reliability accounted for by pooling. If we assumed that the pooling of opinion or the averaging of ratings had an effect on reliability similar to increasing the length of the scale, applying the rationale of the Spearman Brown prophecy formula a reliability coefficient of correlation of 76 between independent ratings would indicate a coefficient of .86 when two judges pooled their interest, and of 90 when three judges participated This reliability is concerned, of course, with the rating at a single time The intercorrelation between behavior indices with ratings were made from 4.8 to 12 3 months apart, with a mean interval of 8 6 was for 25 cases 64

This brief note suggests that the Joel *Scale*, particularly when it is shortened to eight items, is more discriminating in terms of chronological age, and is a reasonably good measure of behavior maturity if chronological age is a criterion of this characteristic.

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BOOKS

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CRITICAL REVIEWS OF RECENT BOOKS

(*Pratt, C. C. The Logic of Modern Psychology. New York: Macmillan, 1939. Pp. 185.*)

REVIEWED BY L. A. PENNINGTON

The author of this volume has attempted to present from his point of view the system of intercorrelates upon which scientific psychology rests. His effort is therefore expended in the direction of indicating the figure-ground relations—to borrow an analogy—within the sciences in which psychology has membership. Indeed, the reviewer looks upon the book as a candid statement pertaining (*a*) to the relations of psychology with sister sciences and (*b*) to the "rules of the scientific game" whereby psychology may eventually attain its maturity. Pratt's pronouncements, though possibly here too briefly put to do justice to the author's lucid treatment, leads one to conclude that any psychologist actively engaged in scientific investigation might well read this volume with profit. The author tells us what pitfalls some encounter and how these pitfalls may be best avoided.

In any attempt to do justice to the writings of another injustice may be done as evidenced by the fact that words are known to have different significations. In guarding against this possibility the reviewer has arranged the major tenets of Pratt's clearly written book into a series of expanded pronouncements not all of which have been specifically so treated by the author. This approach, it is believed, may clarify the basic considerations employed by Pratt in his placement of psychology in the scientific solar system. The first section of this review will thus deal briefly with those considerations which too frequently are not recognized as basic postulates underlying all psychology. The second division, on the other hand, will consist of a brief résumé of those techniques suggested by Pratt, which, if and when applied, will lead psychology from its maze of incompletenesses, dichotomies, and ill-founded theories into the promised land of maturity as a scientific division of labor in its own right.

"Psychology and the Science of Science"[1]

First, Pratt stresses the need on the part of the psychologist to recognize the unity of the sciences. In pointing out that psychology as a science has no subject-matter of its own, he introduces two logically evolved arguments. First, psychology, etymologically speaking, means "a study of the mind." In as much as no scientist has yet been able to establish a criterion for the classification of objects and events into the two overworked categories, mental and physical, there can be no study of the mind *per se*. The subject-matter of psychology is *not* unique. This argument, based as it is on the traditional definition, is followed by a second consideration which leads to the conclusion that the subject-matter of any so-called specific field of scientific investigation is the raw data obtained by way of the sense modes The subject-matter of any science becomes, therefore, by definition, the same. Couching his definition of subject-matter in operational terms, Pratt states that meaningfulness involves "a pointing relation." The meaning of *subject-matter* may then be said to refer or point to the initial data of observation—the "Alpha and Omega of science." Psychology turns out to be merely a branch of the division of labor among the sciences. The author, by way of a large scale illustration, adds that the lines of demarcation between the physical and biological sciences as well as between psychology and philosophy are merely verbal. These lines of demarcation continue to exist chiefly as easy designatory devices for administrators and laymen. The only real difference is one of emphasis and degree on what is and how it is studied.

Second, the psychologist has no logical right to assume that some recorded observations are lawful and others unlawful. On this point he comments:

> Men of science must proceed on the assumption that the objects which fall within their interest and scope of inquiry are subject to law. A scientific law, no matter how complex, rests on the basic proposition, if *a*, then *b*. To proceed on any other assumption is scientific heresy, and deserves the punishment of excommunication Yet there are men who call themselves scientists and believe at the same time in a principal of inde-

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[1] Professor Pratt's discussion is closely related to that presented by S S. Stevens in the *Psychological Bulletin*, 1939, 36, 221-263.

This relationship is indicated in choice of caption used in this review

> terminism. The law which will explain such a paradox will one day have to be formulated by psychopathology (p 28).

Even though the scientist proceeds on this assumption, as he should, Pratt points out that due to the inaccessibility of numerous variables in psychological studies, often assumed to be "chance" factors, our correlations between observed events and concomitant variations in experimental conditions never approach unity. This dilemma, however, can gradually be overcome by rigorous application of techniques implicit, he maintains, in the logic of the scientific method. Determinism in science is essential, nevertheless, as a basic postulate in the backgrounds of those engaged in any scientific endeavor.

Third, the psychologist's rejection of introspection as a method of observation because it is not "objective" is not justified. Historically this problem on methodology arose as a consequence of the problem of the determination of the subject-matter in psychology. Wundt, Brentano, and Watson are said to have been dealing with a problem which was non-existent, since nothing unique by way of subject-matter in scientific psychology can ever be found. Without *mind* introspection merely becomes another symbol for observation. No dichotomy between objectivity and subjectivity need or should exist. The following citation expresses Pratt's attitude on this question.

> It seems unfortunate that psychology should work itself almost to the point of a nervous breakdown because a small number of its initial data have an internal rather than an external localization. All phenomena are private to begin with and become public only when their initial privacy is put into words. Whether they are adequately reported is the only question which concerns science. Thus the phenomenon of objectivity of a datum is wholly irrelevant to its status as scientific material (p. 99)

Each datum, therefore, if adequately reported, should be on a par with each and every other and so by definition be acceptable.

Fourth, the ultimate aim of any science is always prediction and control. This aim, considered from the point of view of operationism and of logical positivism, involves what Pratt terms a "contradiction."

> The only indubitable facts are those contained in the original observations. At time *t*, under conditions *c*, events *e* were recorded. These facts were all in the past the resulting

> laws are still laws of past occurrences And yet science boldly applies many of its laws to events still not in existence Taken strictly, the predicate *true* can apply only to an occurrence which has been found true by direct observation In this limitation lies the inescapable tautology of strict scientific proposition. A future event does not exist and can not be known by direct observation. Therefore all propositions about the future are meaningless, neither true nor false. . . . A tolerable way out of this dilemma is found by accepting the pragmatic value of the notion of probability (p 155-156).

Present day psychology, however, need not greatly concern itself with the problem of prediction and control Its correlations are so far from unity as to preclude any very high probability value. This state of affairs leads Pratt to reiterate the need for reliance upon "science for science' sake." With this as a slogan the practical values from science may gradually accrue. Haste in the search for the practical makes waste. In this connection one cannot but agree that "tentative theories and partial bits of evidence belong in professional journals, not in the public press."

Fifth, scientists must remember that a scientific explanation is always phrased in terms of answers to the questions relative to the *how* and the *what* of a phenomenon. Questions phrased in terms of *why* are unanswerable. "The inability to assign any meaning to the *why* leaves the mystery of the universe just where it always has been and always will be, namely, beyond the range of human solution." Pratt goes on to comment.

> Logic involved in the construction of hypotheses contains a step which to some scientists, particularly psychologists, has always seemed disturbing, even dangerous, and at the best very misleading The arguments are said to be *circular* (italics mine) and it is a time-honored conviction in science that such circles are vicious. This aversion to circular arguments is the last stronghold of that faith which believes that science can furnish for any given array of well-established facts a *why* which is more than a mere statment of *how* the facts go together *Science is a vast and impressive tautology* (italics mine). Its laws are summaries of observations, its hypotheses involve arguments which are circular. Since its explanations are true only if they can be demonstrated empirically, they explain nothing that is not already known. The *why* ques-

tion, unless it means *how* things behave, is forever unanswerable (pp. 149-154)

Sixth, Pratt maintains that it is the task of the scientific psychologist to attain the aim in his scientific division of labor by obtaining for us a scientific "portrait" of "human nature" Although the author unfortunately fails to define operationally or otherwise what he means by *portrait* and *human nature* his usage leads the reviewer to infer that he means a complete scientific picture of *how* and *what* a given human being does under a given series of conditions at specified times[3] In order to arrive at this stage in our knowledge—still considerable distance away from us—Pratt argues that we must study "the immediate antecedents of the initial descriptive data." By means of the method of concomitant variations in the conditions conducive to the induction of a given event it then may become possible to correlate changes in this event with changes in the condition-matrix. Theoretically such correlations should be possible where the antecedent conditions can be isolated for quantification by appropriate methods. Practically, however, this is not the case in contemporary scientific psychology. The majority of these antecedent conditions, thus far inaccessible, has been found occasionally by experiment and has been more often assumed by hypothesis ("set" and "mnemonic trace" are illustrations) to be located within the organism. If these antecedent conditions which influence the appearance of a given phenomenon are eventually found to be as they are postulated "all psychological explanation must move in the direction of physiology." Further, "in proportion as the experimental work in psychology becomes exact, it will inevitably be absorbed into the more basic discipline of physiology" (p. 133) Thus if the "portrait" of "human nature" is to be scientifically formulated the *how* and the *what* of it will illustrate once more the fundamental unity within the sciences

As a corollary of this pronouncement Pratt holds that the available psychological laws are far from being causal They are only crudely and essentially empirical This statement indicates how it is that our probability values in psychology are so low and how it is that numerous gaps exist in our understanding of the *how* and the *what* of many initial observations In fact, it is to be observed, those sub-psychological fields in which the greatest practical value might well accrue (social, applied, educational "psychologies," for instance) are those in which our laws are the most crudely empirical if not more correctly plainly intuitive in their natures. On the other hand, the correlations obtained in the studies on sensation and reflexology are much more complete.

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[3] This statement appears consistent with the text

Seventh, psychologists should take an inventory of the concepts in common usage *and shear them of their ambiguous meanings.* Many a concept, though not all, contains a meaningful core which could, if its inventor would, be operationally defined. Into the periphery of these concepts, in addition, there has crept hazy, elusive, changeling elements of a more indefinable nature. These hazy, meaningless, turncoat accumulations prevent the concepts from being considered coincidental with the initial observations upon which they rest for empirical validation. This difficulty in interpreting the meaning existent in a given symbol may be accounted for in general in two ways First, inferences from collected data frequently are *reified* until the designating symbol comes to be referred to as a *thing.* The concept of personality trait is assumed by Pratt to be an illustration.

> Thus trait has parted company with behavior and has acquired undefined notions in its flight from reality. Eventually trait has come into an existence all its own, so that when it is said that a man has courage he will be thought of as a fortunate owner of something considerably more significant than a certain pattern of behavior (p. 115).

Second, symbolization of initial observations may become so generalized in application with passage of time that these additional and variable elements so accumulated may be said to have *infiltrated* the original meaningfulness of the concept designation. Because most scientists do not restrict their use of concepts to those operationally definable and because any hypothesis used to account for the data summarized in the concept is likely to be identified with the symbol itself, many concepts become more and more ambiguous with the passage of time. Thus here lie two major difficulties in the attainment of a degree of clarity in thinking.

The other side of the question of concept ambiguity, however, is different. Pratt states what several other exponents of operationism in science have refused to admit when he says that the construction of absolutely pure operational meanings is not only practically impossible, but not always even desirable Inasmuch as the psychologist is not primarily concerned with raw data as such but with the extension of our generalizations and laws it becomes increasingly clear that infiltrated and reified concepts when checked against the data basic for their meaningfulness, may present leads to further scientific experimentation. Concepts which occasionally get slightly out of bounds may thus result in experimental tests The paradoxical role of the reified and the infiltrated conceptualizations thus becomes obvious.

In summary, the psychologist, assuming a deterministic system, should be concerned in the attainment of the "portrait" of "human nature." This will obtain only by the psychologist accepting the dictum that mere accumulation of quantified and classified data is not enough He must, in addition, answer the *how* and the *what* of these data and thereby illustrate the absence of anything unique in psychological subject-matter

RAPPROCHEMENTS

The following points have been abstracted from the discussion presented by Pratt and have been held by the reviewer to represent suggested steps, inherent long since in the logic of the scientific method, which will make for rapprochements between scientific psychology and the other divisions of scientific labors

First, the psychologist should continue to eliminate the sources of error involved in observing and recording objects and events occurring in complicated relationships. The rule of thumb pertaining to the quantification of these observations should continue to be the ideal sought for by all scientists. In so doing the psychologist should remember that both consistency and reproductibility of observations still remain the criteria by means of which valid inferences and generalizations can eventually be constructed with the help of operational practices To quote.

> Whenever in a scientific setting, a given protocol is returned with reproducible consistency, it becomes the starting point for the formulation of propositions and concepts.

These generalizations and inferences must be zealously guarded in order to prevent their being abstracted from their scientific settings and thus from the operations used to observe and record them. The psychologist can best guard against this treatment of the concept as a *thing* by observing and reporting upon a single item at a time and by varying single variables from scientific setting to setting in the attempt to determine the rôles of antecedent conditions conducive to the production of the given event. The psychologist thus must go on with his careful study of the phenomena which interest him.

Second, scientists should establish as one of their goals the rule of attributing meaning to their concepts by recourse to operational terms. The concept and the definition, as synonymous terms for Pratt, must always be based upon the data to which we may point when asked the meaning of a given symbol. He continues:

> The observational data . . . cannot themselves be merely definitions, otherwise, the validity of a definition could be tested not by a return to observations and fact, but only by verbal analysis of a further definition, which definition in turn would only be tested by additional definition: an endless regress which would turn the serious game of science into a mere play on words (p. 109)

Operationism thus becomes a technique by means of which the jump from the datum to the concept and from there to the hypothesis can be less painfully and more accurately and meaningfully made. Any such concept which illustrates functional equivalence with the initial datum of observation is labelled by Pratt as a *material property* in science. This property points for its meaning to those events or objects which were directly observed. This material property, further, is of no great significance in and of itself. It has scientific value only when it is made use of by the scientist in the erection of additional concepts which may take the form of inferences, generalizations, hypotheses, and the like.

An additional usage of the logic of operationism in scientific psychology entails the formation of *formal properties*. This formal property, which follows upon the material property, is of necessity constructed on the basis of the latter. This new property may

> suggest items in terms of which the observations may be explained. An element of non-operational meaning has entered

> in But this element is not of scientific nonsense, for its meaning is governed by the observations

In this way the imagination of the scientist is so operationally carried on that the scientific guesses are held down by the initial data. Pratt illustrates these two properties in science by reference to the manner in which the formal property of the *blind spot* might have been evolved.

> A person holds a paper in front of him, closes his left eye, and fixates the black dot with the other eye . . If, after a time, he brings his observations together and summarizes them by some phrase—he may decide to call the thing *peripheral anopsy*—that phrase defines the material property As far as sheer observed correlation goes, here the matter ends But our amateur scientist insists on being his own physiologist He makes a very plausible guess that a certain region of the retina must be insensitive to light By using his initial measurements and doing some simple calculating, he can make a good estimate as to the location and size of the insensitive region Moreover, he calls this region the *blind spot*, and he can say exactly what he means by that phrase in terms of his observations and calculations The blind spot is a formal property, for it is not observed, but its characteristics were derived from what was observed. It is a sound logical inference, a good guess, a justifiable conceptual reification It raises a clearly defined question for physiological optics to answer. Material properties are of little importance in and of themselves. The formal properties which the material properties define are the important concern of science (pp. 139-140)

It is believed that this quotation illustrates simply and clearly the rôle of operationism in the formation of hypotheses Any hypothesis, accepted by Pratt to be the life blood of science, must therefore fit the gap in the information supplied by the first generalization. Further, this hypothesis must be given a locus as well as a linguistic formulation both of which make possible an experimental test. Operationism comes to act as a weaver's shuttle by means of which the threads of the operationally defined material property are interwoven with others logically evolved into the experimentally verifiable pattern of the formal property.

Third, the psychologist must realize the necessity for the adoption of the attitude of "science for science's sake" This banner must be raised high and must be accepted by administrators and by laymen as well as by psychologists. Only in this way can the laws which are assumed to exist within this presently undeciphered "portrait" of "human nature" be formulated and applied.

> For a long time to come psychology should remain in the laboratory and the library. If the general public is not fully aware of what is going on there, so much the better.

The reviewer, in attempting an evaluation of this logically written volume, has the following comments to make. He feels that Pratt should have had no fear of ostracism for having written what amounts to a critical inventory of scientific theory and practice as a contemporary psychologist views them. He believes that Pratt could have improved upon the effectiveness with which the material is presented by incorporating in a rigorously written summary the pronouncements in crystal clear fashion. Repetition of the major "ifs and oughts" for scientists would not have been any more disturbing He feels that the author might have been more dogmatic in his establishment of dictates which should be accepted and followed in the conduction of any investigation, psychological or otherwise in nature. He finds that Pratt has exaggerated at times the sad plight (according to the author) of contemporary psychology the better to make his points. On the other hand, the reviewer is of the opinion that the proof that Pratt is unquestionably wrong in any one of his critical pronouncements lies with those who do not believe one or all of them. He believes that these critics will have to prove that all which is done today under the vestments of "science," as looked upon by Pratt, is completely scientific. He believes that those who are confirmed "mentalists" (with or without the capital *M*) will have either to establish the criterion for the validation of their dichotomy between the so-called mental and physical or accept Pratt's critique. He believes that those who maintain that behavior is adventitious, occasionally due to "chance" factors, will either have to prove their indeterminisms or accept Pratt's reiteration of determinism. He believes that the statistical "correlationists," either ignoring or designating as constant the operation of unknown variables, according to Pratt, will of necessity have to prove the validity of their rejections in the final analysis. Whatever the answers, the reviewer maintains that Pratt has presented in six chapters a challenging, critical view of what scientific psychologists do and do not as well as should do by way of their usage of the scientific method.

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(Newman, H. H., Freeman, F. N., & Holzinger, K. J. Twins: A Study of Heredity and Environment. Chicago: Univ. Chicago Press, 1937. Pp. 369.)

REVIEWED BY LOUISE BATES AMES

The title of this book is rather misleading if it causes the reader to expect definite conclusions as to the relative importance of heredity and environment in influencing the development of twins It seems apparent that the authors' answer to the long-debated problem is a common-sense one. Whereas a co-twin control experiment may demonstrate the ineffectiveness of training in markedly hastening the onset of some specific activity, so far as the more general question of environment vs heredity is concerned, it appears as yet to be difficult even by an elaborate and extensive research program either to set a crucial problem or to reach significant conclusions. The authors themselves state

> The farther one penetrates into the intricacies of the complex of genetic and environmental factors that together determine the development of individuals, the more one is compelled to admit that there is not one problem but a multiplicity of minor problems—*that there is no general solution of the major problems nor even of any one of the minor problems.*

Part One, *Introduction and Biological Aspects,* chiefly presents a careful summary of previous studies of twins and a critique of methods used in these studies It also considers the problem of diagnosing monozygocity, and points out the unreliability of the "membrane" method. The so-called "similarity" method of determining monozygocity, which the authors favor, is described

The causes of differences in identical twins reared together are discussed in detail. The authors say.

> One of the most striking facts that came to light in our studies of identical twins reared together is that the two members of a pair are never truly identical but differ more or less with respect to all their characters, and that they differ sometimes to a disconcerting degree

It is suggested that the common assumption that differences between identical twins are due wholly to intangible differences in the postnatal environment overlooks the possibility that at least some, if not most, of the differences are the result of causes which are associated with the monozygotic twinning-process and are peculiar to that process. The chief prenatal causes of differences between identical twins are classified as (*a*) the fusion of fetal blood vessels between twins and the consequent inequalities of the blood supply, and (*b*) the asymmetry mechanism These two factors are discussed in detail

Part Two compares 50 pairs of identical with 50 pairs of fraternal twins, reared together. An extremely detailed statistical résumé "presents in systematic and statistical form those facts concerning the twins which formed the basis of the differentiation" The two kinds of twins are compared on a large group of physical and mental traits. The general conclusion reached in this section is that: "The contrast between identical and fraternal twins is greater in some traits than in others, being greatest in number of finger ridges and, in general, somewhat less in mental than in physical traits. This fact suggests that some traits are more susceptible to environmental influence than others."

The provisional hypothesis is presented that:

> Behavior and mental ability are more subject to the influence of training and environment than are physical size, form, and features such as color of eyes, color and texture of hair, etc It is quite plausible to suppose that the nervous system, which is the physical counterpart of mental traits, of behavior, and of abilities, being more subject to influence by stimulation from the external world, is also more susceptible to variations through much stimulation and through the responses which are made to it

By assuming that identical twins have identical heredity, while fraternal twins do not, the authors believe that they may set up certain formulas for evaluating the relative influence of nature (genetic factors) and nurture (prenatal and postnatal environment) They present a statistical analysis of the 100 pairs of unseparated twins. Of particular interest is a table which gives the relative importance of genetic and environmental factors. Of 23 comparisons made, in only six instances is the genetic factor less than .50. In the case of physical traits the genetic values range from .75 to .90;

for intelligence, from 65 to 90. Even in the Stanford achievement tests the genetic values average 64. The traits for which the genetic factors count less than 50 are. Stanford achievement tests for arithmetic computation, nature study and science, and history and literature, Woodworth-Matthews score, and tapping speed Another interesting table (Table 25) gives the raw intraclass correlations between twins (identical and fraternal treated separately) for these same traits, correlations of traits with age, and resulting partial correlations A similar statistical analysis of the separated twins is presented later in the book

Part Three discusses 19 pairs of identical twins raised apart The separations took place when the subjects were from two weeks to six years of age, being before the end of the first year in 12 cases. The authors believe that complete separation is not as important a factor as pronounced difference in environment They state that more or less visiting between separated twins did not tend to vitiate the experimental aspects of separation, as shown by the examination of Case IV, where the twins lived only a few miles apart and saw each other frequently This pair turned out to be one of the most different mentally, temperamentally, and physically; while some of the cases that were absolutely separated, but in whom the environmental factors were not very different, turned out to be very similar in those respects "All this goes to show that mere separation is ineffective in producing differences and that, only when marked differences in the environment occur, are twins likely to show differences of a significant sort" This is only a necessary explanation, however, if we make with the authors the assumption that identical twins have identical heredity. Otherwise we might assume that marked similarities and marked differences are perhaps not "caused" by either similar or dissimilar environments, but may be due to hereditary factors

The 19 case studies are clearly and interestingly presented Information given about each pair of twins includes data on educational careers, social and physical environments, physical resemblances and differences, tests of ability, tests of personality, samples of handwriting, and for all but one pair of twins, comparative photographs, which add a great deal to the presentation.

The conclusion is reached that 14 of the 19 pairs represent very close agreement between education and ability, and that five cases represent moderate discrepancy. The authors admit that their analysis is weighted in favor of the environmental interpretation They say, "This weighting is due to the fact that the case studies represent an attempt to find indications of a correlation between environmental differences and differences between the twins Some of the correspondences found may be coincidences."

This admitted bias probably accounts for the fact that we find among the 14 cases in which differences in ability are correlated *positively* with differences in the environment (according to the authors), such cases as the following:

> *Georgiana and Eleanore* With 10 years difference in schooling there is still only two to four years difference in general intellectual ability and in general scholastic attainment as measured by the tests, with personality differences less marked
>
> *Raymond and Richard* Tested at 13½ years of age, these twins were "very similar indeed", both in ability and behavior "We might expect close similarity in ability from the similarity in schooling, but the considerable difference in social and physical environment might have been expected to produce greater differences in personality"
>
> *Mary and Mabel* Mary, who had more schooling, made higher scores on the test of intelligence and educational achievement, but Mabel equalled her sister on the International Test In temperament, the difference was small.
>
> *Ada and Ida.* One was brought up in the city, the other on a farm, quite different environments, but they were at fifty-nine "equal in mental rating and very similar in temperament"
>
> *Olive and Alice* These girls had very different environments But in spite of having been separated, and in spite of quite different educations, "in personal appearance, manner, and general behavior they are probably more alike than the average siblings or fraternal twins."

Of the five pairs which represent moderate discrepancy between education and ability, four pairs are described as "difference in education negligible, difference in ability negligible with one or two exceptions.' The fifth case is classified as "difference in formal schooling large, but not accompanied by marked difference in ability" It is summarized as follows:

> *Thelma and Zelma* Their early environments were rather different and there was a difference of about five years of school-

> ing between them, "a difference which is reflected only very slightly in the intelligence tests . In spite of the considerably longer schooling which Thelma has enjoyed, the abilities of these twin sisters are approximately the same The tests of personality indicate close basic similarity "

Anyone less interested in the effects of environment than in the persistence of inherent similarities in spite of different environments might classify the 19 cases somewhat differently It is noteworthy that the authors, in spite of their theoretical bias, have not failed to include results which strongly suggest the importance of genetic factors.

The impression increases, as one finishes this section of the book, that the authors are not attacking the problem (if it is a problem) of heredity and environment so much as illustrating the fact that educational advantages are as a rule reflected in, and influence, scores made on educational tests, and that identical twins with different environments but similar educational advantages will show little difference in test scores The authors seem, much of the time, to be stressing "education" rather than "environment" as contrasted to heredity They state, "fourteen pairs represent very close agreement between education and ability and in no case is there a significant difference in ability in the opposite direction to a significant difference in education "

Personality differences between the twins are discussed for each individual case, since it was found to be impossible to classify the cases with respect to the relation between personality differences and environmental differences as was done for ability differences. Several of the pairs of twins were found to be very similar in personality and temperament It was observed that for some kinds of "personality" traits more twins were alike than for others. Pairs of twins were found to be strikingly alike, for instance, on the Downey *Will-Temperament Test,* five being almost identical, ten similar in a considerable part, and only four widely different. In contrast, only two pairs of handwriting specimens were noted as closely similar and twelve were widely different Contrast in the form and even in pressure of the specimens written by one pair (Case XVIII) is put into sharp relief by the fact that the writing of both had a common and peculiar (for young men) characteristic, namely, a pronounced tremor. Here we find a contrast between a fundamental and a derived characteristic in the same activity.

In this connection, the hypothesis is suggested that there are several levels of behavior. Certain behaviors are determined largely by the original character of the organism. These are not impervious to influence but may not be greatly modified because they have not been incorporated into an organized system of learned behavior. On a higher level are the forms of behavior which constitute the adjustment of the individual to his environment. These are the product of both the organism and the environment interacting and are affected both by original nature and by environment. Such characteristics as the muscular tremor of Case XVIII are of the first type; whereas handwriting and responses on tests of emotions and of neurotic dispositions are of the second The reactions on the Downey tests represent modes of behavior somewhere between these two extremes.

Among the most definite conclusions which are reached are the following from the last chapters of the book:

> "The relative effect of hereditary and environmental differences is also a function of the type of trait. Any fixed ratio of these two factors for all traits and conditions is thus impossible . For the rest it is obvious that the twins who have the same environment are the more alike By and large, this indicates, since the environment is similar for both groups" (used in this study) "that genetic constitution is a large factor in physical dimensions (as well as appearance and qualitative differences), mental ability, and educational achievement This conclusion seems clearly warranted"
>
> "It appears that the physical characteristics are least affected by the environment, that intelligence is affected more, educational achievement still more, and personality or temperament, if our tests can be relied upon, the most . Our index shows that about 25 or 30 per cent of the variance in intelligence in fraternal twins reared together may be attributed to environmental influence"
>
> "A further argument pointing to the limitation of the effect of environment is that the differences between a majority of the separated twins, namely those who have been brought up in similar environments, are no larger than are to be found among the unseparated pairs In fact, if we eliminate some half-dozen pairs from the separated cases, the average differences of

> the remainder are about the same as those of the unseparated groups."

Anyone reading this book with the expectation of finding a definite answer to the problems which have long been posed as to the relative importance of genetic and environmental factors in determining the behavior of twins, may be disappointed But for those who are not chiefly interested in a basic analysis of the problem, the book presents a wealth of interesting and detailed case material, an amount of factual material about twins considerably surpassing anything else that has been published to date The suggestion arises, however, that real progress cannot be made in twin research, and that the full value of twin study as a scientific tool will not be realized, until a careful analysis and redefinition of all the major problems involved have been made

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BOOKS RECENTLY RECEIVED

(There will always be two pages of book titles, listed in the order of receipt, i.e, the most recently received books will be found at the end of the list)

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Child Behavior, Animal Behavior, and Comparative Psychology

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The Journal of Genetic Psychology, 1940, 56, 247-263

THE ONTOGENETIC ORGANIZATION OF PRONE BEHAVIOR IN HUMAN INFANCY

Clinic of Child Development, Yale University

Arnold Gesell and Louise B Ames

This paper aims to bring into panoramic view the total sweep of development reflected in the patterning of prone behavior in the human infant from one week through 60 weeks of age. A more complete survey of the ontogenesis would have to include the vastly complicated and largely unknown chapter embraced by the fetal period The preschool period might also be profitably investigated to determine to what extent the developmental trends of the prone patterns of infancy are continued in the postural behavior of the walking child.

The scope and situs of the ontogenetic changes in the first year of life can be summed up in a preliminary way as follows.

Head

The head lifts from the floor through an arc of 90° or more

Arms

The arms, at first sharply flexed, extend forward, later they flex inward under the chest, and come to extension from shoulder to floor at right angles to the trunk which is at first supported on the forearms and in time on the hands

Legs

The legs extend backward, lift, later they flex forward beside the trunk, and then under the trunk, supporting its weight on the knees In time the legs like the arms come to right angle extension, supporting the trunk on the feet

Trunk

The trunk, at first convex, flattens, concaves, then flattens again upon elevation above the ground surface The trunk is in horizontal or oblique alignment until the assumption of the upright posture

A. Developmental Stages

All these manifold changes of pattern come about gradually and concurrently In deep perspective they may be envisaged as a single flow of postural transformations Although the ontogenetic flow is continuous it is possible to identify at least 23 moments in which the patterns of behavior assume a distinctive form. These moments and the intervals between them are conveniently called stages But the morphogenesis of patterns never comes to rest, it proceeds incessantly. A stage is in reality a degree of maturity, evidenced in a characteristic pattern of behavior. A cycle is a continuum of closely related stages. Our task is to discover lawful trends in a fluent succession of stages and cycles.

We have studied the ontogenetic stages at daily, weekly, and monthly intervals in individual infants and groups of infants The basic data consisted of extensive cinema records of the prone behavior of 12 normal children of average and high average mentality. The records included spontaneous and induced behavior, both under naturalistic and normative conditions. The infants were placed prone on a flat surface, softened when necessary with cloth or other covering. At appropriate ages a lure (bell or rattle) was used to elicit postural and locomotor activity The procedures used in the normative observations and in the cinemanalysis of the data are described elsewhere (7, 11, 12, 13).

The development of prone behavior and locomotor mechanisms in the lower animals has had considerable attention in zoological and neurological studies: Avery (2), Coronios (6), Jacobsen (15), Langworthy (16, 17), Laughton (18), and Stillman (21) Creeping and crawling in the human infant have been investigated by various authors: Brown (3), Burnside (4) Hrdlička (14), Shirley (19, 20), and Trettein (22). An earlier study, *The sequential patterning of prone progression in the human infant* by Ames (1) details 14 stages observable from 28 weeks to one year of age. The present study outlines a comprehensive series of stages beginning at one week of age; and is also designed to serve as an interpretive key to a silent film: *Prone progression in the human infant,* which depicts the whole gamut of stages (Gesell, 9)

The distinguishing features of 23 stages are summarized in Table 1, with special reference to the following categories:

I. Flexor versus extensor dominance
    Abduction and adduction
II. Bilaterality versus unilaterality.
    Ipsilaterality versus crossed laterality.

This tabulation outlines what may be regarded as an ideal sequence.

TABLE 1

DEVELOPMENTAL STAGES OF PRONE BEHAVIOR IN THE HUMAN INFANT

(The age at which a given action pattern typically makes its appearance is indicated in parentheses)

Flexor dominance	*Extensor dominance*
1 *Passive kneel* (1 week) Both arms and both legs are *symmetrically* and sharply *flexed*. Cheek contacts platform, or head may be everted.	
	2A *Passive leg extension* (4 weeks) The legs passively assume a *symmetric* extended posture Arms still *flex*, fists at shoulders Head lifts slightly less than 45°
2B *Active kneel* (about 4 weeks) Infant spontaneously draws up one knee at a time by (*unilateral*) *flexion*	
	3A *Active leg extension* (8 weeks) Legs actively assume a *symmetric* extended posture Arms *flex* slightly forward
3B *One knee thrust* (about 8 weeks) Infant spontaneously draws up one knee by *flexion* with an abducted thrust (*unilateral*) Head lifts from 45° to 90°	
	4A. *Alternate extensor kick* (12 weeks) Infant lies with legs well *extended* and kicks in *alternation* Fists at temples Head lifts slightly.
4B. *Abducted one knee thrust* (about 12 weeks) Infant draws up one knee by *flexion* with increased abduction (*unilateral*) Head lifts 45° to 90°	
	5 *Swimming* (16 weeks) Back arches so that infant's weight rests on abdomen and lower chest Arms lift, *flexed symmetrically* Legs lift, in *symmetric extension* Head lifts 90°
6 *Simultaneous low creep* (20 weeks) Both arms and both legs are *flexed symmetrically* Face and chest contact the supporting surface but abdomen is lifted	
	7 *Frogging* (24 weeks) Arms are *flexed* or *extended symmetrically* Legs are *extended symmetrically* in abduction, feet everted Head lifts 90°

TABLE 1 (*continued*)

Flexor dominance	*Extensor dominance*
8 *Advanced unilateral knee thrust* 9 *Same with foot eversion* (28 weeks) Both arms *extend symmetrically*, or one *extends* and one *flexes*. Infant draws up one knee by *flexion* with an abducted thrust. (9) Same except that foot is everted. Head lifts 90° or more.	
	10 *Pivoting* (29 weeks) Arms alternately *flex and extend*, one after the other, causing trunk to pivot on abdomen. *Symmetrical* leg extension is followed by forward *flexion* of one knee, in abduction. Head lifts about 90°.
11*A* *Inferior low creep* (30 weeks) Arms flex symmetrically. One knee *flexes* forward in adduction. Other knee then *flexes* forward after heel has rotated outward. Weight rests on side of body. Head everted, cheek on floor.	
	11*B*. *Backward crawl* (31 weeks) Legs *extend symmetrically* and passively and abdomen rests on the supporting surface. Infant pushes body backward from *symmetrically flexed* arms which come to *extension* as body pushes away from them. Head lifts less than 90°.
12. *Low creep* (32 weeks) Both arms are *flexed symmetrically*. Legs *flex* forward in adduction, *one at a time*. Face and chest contact supporting surface but abdomen is lifted.	
	13*A* *Crawling* (34 weeks) Legs *extend symmetrically* and are dragged forward passively. Infant pulls trunk forward by *extending* then *simultaneously flexing* both forearms. Head lifts 90° or more. 13*B* Later (34½ weeks) Pulls weight forward by *extending* and then *flexing* forearms *one at a time*.
14 *High creep* (35 weeks) Both arms are *extended* and both legs are flexed *symmetrically*. Knees are forward under trunk in adduction, lifting abdomen and chest from	

TABLE 1 (*continued*)

Flexor dominance	*Extensor dominance*
supporting surface Head is well up from floor and eyes look ahead	15 *Backward creep* (36 weeks) Infant is in the high creep position Extends first one leg then the other, lowering abdomen and falling backward Arms are *flexed symmetrically*
16 *Rocking* (about 36 weeks) Arms *extend symmetrically* and Both legs are *flexed symmetrically* Knees are forward under trunk lifting abdomen and chest from supporting surface Infant rocks back and forth, remaining in one location	
	17 *Creep-crawl* (37 weeks) In high creep position, both arms *extended* and both legs *flexed* Falls forward, both legs coming to *extension*. Arms *extend* forward and infant attains high creep position again Progresses in this fashion
18 *Creeps* (40 weeks) 19 *Creeps, near step one foot* (42 weeks) Both arms *extend downward* from shoulder, then *extend* forward, alternately Legs *flex* forward *alternately* Arm and leg on opposite sides of body move simultaneously.	
	20 *Creeps, step with one foot* (45 weeks) Arms *extend* forward *alternately* Legs move forward *alternately, one flexed, one extended* 21*A* *Plantigrade position* (49 weeks) Arms and legs both *extend* downward 21*B* *Plantigrade progression* (49½ weeks) Arms and legs *extend* forward, alternately; left hand and right foot moving at same time 22 *Standing* (56 weeks) Trunk upright Arms and legs *extend* bilaterally 23 *Walking* (60 weeks) Arms and legs both *extended*, move *alternately*

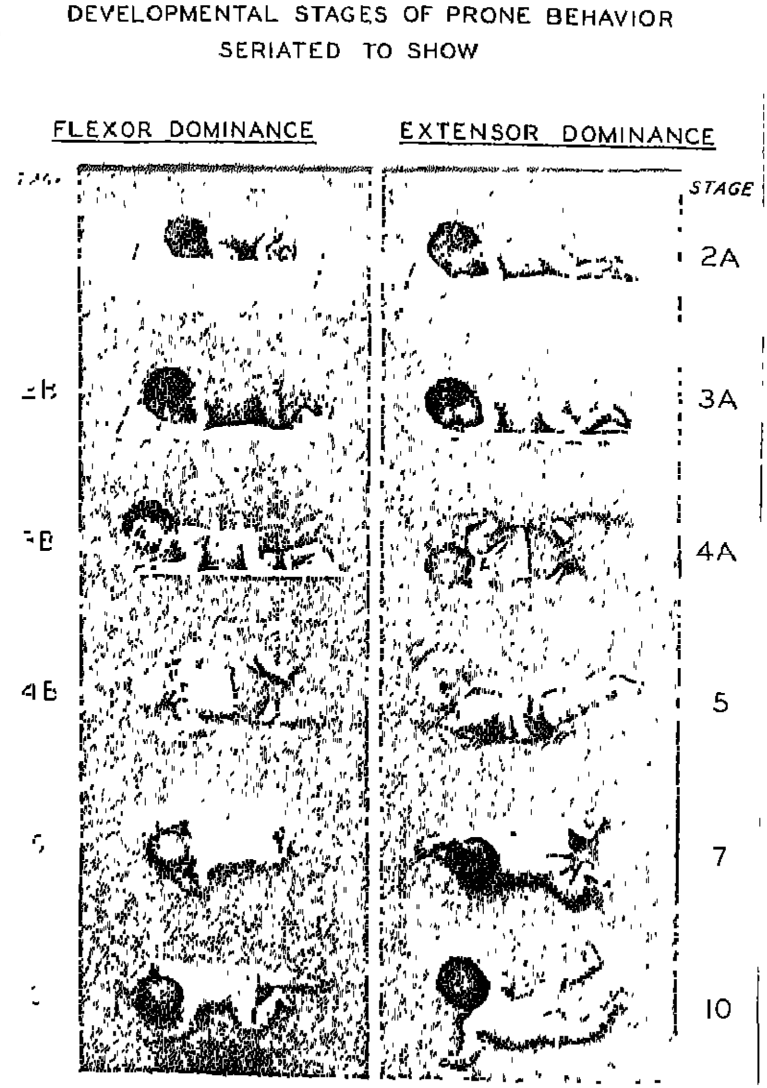

FIGURE 1*A*
PICTORIAL CONSPECTUS OF THE ENTIRE SERIES OF DEVELOPMENTAL STAGES

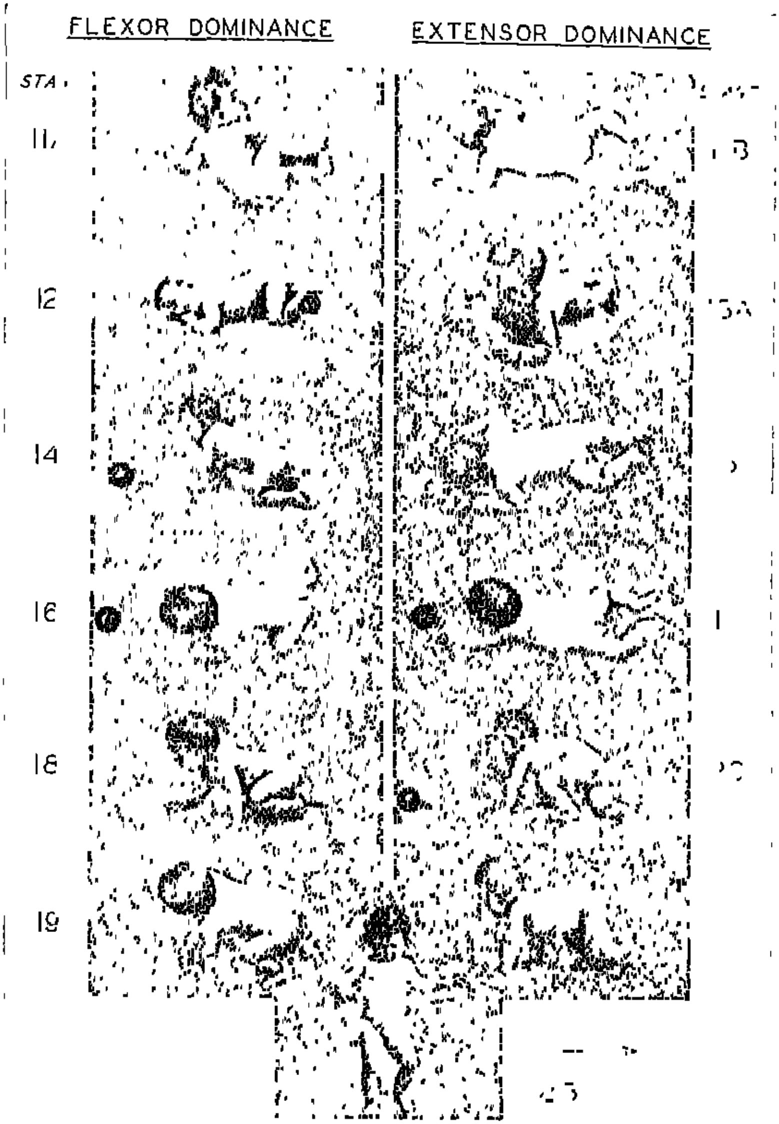

FIGURE 1B

Every one of the foregoing stages has been observed in a number of children but not all of the stages have been observed in all of the children. For example, in 20 cases under observation from six months to one year, 93.5 per cent of all possible stages were observed, that is 262 stages out of a possible 280 stages (1). A few of the stages listed in the table are almost evanescent but they cannot be excluded from a complete outline of the ontogenetic sequence

Phylogenetically the upright posture is a relatively recent acquisition. It is therefore not surprising that there are many individual variations in the timing and duration of the pre-upright stages of postural behavior. To some extent, however, these variations are artifacts, due to incompleteness of observation If we had adequate control of environmental factors and of the periods of observation, it is highly probable that all or nearly all of the stages above listed would make their appearance in a normal infant.

It should also be pointed out that contiguous stages are not neatly separated in the activity of the infant During the course of a day, an hour, or indeed of a minute, he may display two or three closely related patterns or stages: (*a*) a pattern which he has almost outgrown but reverts to for pragmatic reasons, (*b*) the pattern which is most characteristic of him at his level of maturity; (*c*) the pattern which is so nascent that he uses or manifests it only sketchily and imperfectly Inasmuch as no pattern is structurally or functionally altogether discrete, he naturally presents "mixtures" and "regressions" which may be confusing to the observer; but which are, nevertheless, quite compatible with the mechanism and the sequence of normal development

A pictorial conspectus of the entire series of developmental stages and substages is presented in Figure 1*A* and Figure 1*B*. Each stage is illustrated with a representative action photograph. Standing and walking may be regarded as culminating stages because, teleologically considered, the development of prone behavior is directed toward upright locomotion.

In a few instances substages are indicated, to bring into relief the developmental components of a given pattern. A substage may be regarded as a stage within a stage, separated by a rather brief interval of time. The process of morphogenesis lingers long enough in the shaping of some phase of a complex action pattern to give the substage a separable status in the total sequence

1 *Flexor vs. Extensor Dominance*

Flexion and extension are the two most fundamental components of muscular movement In the ontogenesis of the neuromotor system a complicated integration of opposed muscles is progressively achieved. The patterning of prone behavior involves a changing counteraction and correlation of these motor antagonists. The end-results of the underlying growth processes are reflected in a shifting of flexor and extensor dominance

Flexor and extensor phenomena rarely occur in complete dissociation The relationship between the two is a reciprocal one It is possible, however, by naturalistic observation of the infant's behavior and by naturalistic and quantitative study of the cinema records of this behavior to determine at any given stage whether flexor or extensor characteristics prevail (*a*) in postural attitudes, (*b*) in postural movements.

a. Postural attitudes of trunk and legs The restrictions and shape of the uterine cavity impose upon the fetus a curled up flexor attitude. The newborn infant reflects this flexor habitus As he grows older he straightens out because of an increasing dominance of the extensor components in his musculature. There are also, of course, concordant skeletal and articular changes By the age of four weeks he assumes and sustains for long periods a definitely extensor attitude in which the trunk lies flat on the ground surface and the legs are extended centripetally along the floor (or even above the floor, as in the swimming attitude, Stage 5). At Stage 6 he assumes a low-creep position which is a flexor attitude. At other stages as well the upper leg flexes for brief periods but the basic attitudes are predominantly extensor, until Stage 12 which ordinarily occurs at about 32 weeks Accordingly the period from four weeks to approximately 31 weeks is considered an extensor era

At Stage 12 the flexor attitudes come into prominence and remain so until Stage 20 From time to time the infant assumes attitudes which are extensor in character, but these are temporary and chiefly involve the lower leg The basic postural attitudes of trunk and upper leg are flexor, and the period between 32 weeks and 42 weeks may therefore be regarded as a flexor era

At Stage 20 one leg comes into full extension and one foot is planted on the ground This heralds an extensor era in which both legs come into increasing extension, eventuating in the upright posture (Stage 22)

In summary, four eras may be distinguished in the ontogenetic moulding of the attitudes of the prone trunk and upper leg, namely (*a*) a neonatal era of flexion; (*b*) an era of extension from four weeks to 31 weeks; (*c*) an era of flexion from 32 to 42 weeks; and (*d*) a final era of extension from 45 to 60 weeks.

b *Postural movements.* Flexor and extensor movements physiologically occur in close reciprocal association. In any fully matured or established pattern they are well balanced; neither is in marked ascendancy. During the development of a complex action system, such as prone locomotion, there is, however, a progressive shift of emphasis now on flexor and now on extensor movements. With the aid of repeated cinemanalysis each developmental stage was examined to determine which type of movement was most prominent or most characteristic. When flexion and extension were almost equal, the stage was classified as flexor (or extensor) if the new, nascent movement characteristic of that particular stage began with a flexion (or extension) of the critical members.

Using these criteria it was possible to range the stages (and substages) in two parallel columns, denoting respectively flexor or extensor dominance (Table 1 and Figure 1). It will be noted that sometimes two or more contiguous stages are listed in the same column Viewed in perspective, however, a more or less rhythmic alternation becomes apparent. This fluctuation suggests a mode of growth, a process of reciprocal reincorporation, which brings flexors and extensors into progressive interrelation. Reciprocal interweaving proves to be as pervasive as the cephalo-caudal principle of developmental direction (8).

2 *Bilaterality vs. Unilaterality*

The human infant in the first year of life is something of a taxonomic hybrid. He classes both as *Bimana* and *Quadrupeda.* The organization of his prone behavior patterns entails shifting trends toward bilaterality, unilaterality, ipsilaterality, and crossed laterality among his two pairs of extremities. These developmental shifts are not as frequent as those of flexor-extensor dominance, and they seem to occur somewhat independently of the latter. The total pattern of behavior characteristic of any stage of maturity is a kind of algebraic complex of the prevailing laterality trend and of the flexor-extensor dominance.

These laterality trends may now be summarized with respect to (*a*) postural attitudes of arms and legs, (*b*) postural movements.

a Postural attitudes of arms and legs. The *arms* assume a symmetric or bilateral position through Stage 7 (about 24 weeks). In Stages 8, 9, and 10 (28 to 29 weeks) arm postures are mostly unilateral. Arms again assume bilateral attitudes throughout Stages 11 to 17 (32-39 weeks); they are again mostly unilateral from Stages 18 to 23, that is from 40 weeks onward.

Leg attitudes are predominantly unilateral through the first four stages, though bilateral attitudes frequently occur, bilateral from Stages 5 through 7; unilateral from Stage 8 through 11, bilateral from 13 through 17, and unilateral for the most part after that

b Postural movements. Coghill, on the basis of observations of amblystoma, has pointed out that limbs act together under dominance of the trunk before they are ready to act individually of their own accord He refers particularly to the early stages of locomotion (5). In the human, this principle is by no means confined to the more primitive stages It comes repeatedly into operation at advancing stages of maturity, as though a spiral kind of process were at work to bring unilateral and bilateral movements into reciprocal interaction without sacrifice of consolidation.

Significantly enough there are at least eight instances in the ontogenetic sequence where the bilateral behavior pattern of one stage is immediately or soon followed by a similar but unilateral behavior pattern Three of these eight instances of bilateral-unilateral transition arise in flexor stages; five in extensor stages as follows:

Flexor Stages

(*a*) *Bilateral Stage 1 Passive kneel* Both knees are flexed forward passively under the trunk.
Unilateral Stage 2B Active kneel Knees flex forward one at a time, somewhat under the trunk.

(*b*) *Bilateral: Stage 6 Simultaneous low creep* Knees flex forward simultaneously under trunk; shoulders are low.
Unilateral: Stage 11. Inferior low creep Knees flex forward alternately but trunk tips to weight on one hip.
Unilateral Stage 12 Low creep Same, but trunk remains straight as knees go forward alternately, well under trunk.

(*c*) *Bilateral Stage 14 High creep* Both legs flex forward under trunk.
Unilateral Stage 18 Creeping Both legs are flexed, but move forward one at a time.

Extensor Stages

(*d*) *Bilateral Stage 3A Active leg extension* Both legs extend, actively and symmetrically

Unilateral Stage 4A Alternate extensor kick. Legs extend and kick, alternately
Bilateral Stage 5 Swimming Legs extend upward, symmetrically.
(e) *Bilateral Stage 7 Frogging.* Both legs extend symmetrically in abduction
Unilateral, Stages 8, 9. Advanced unilateral knee thrust One knee flexes forward abductively
(f) *Bilateral: Stage 13A Crawling* Pulls weight forward over both forearms at once
Unilateral Stage 13B Crawling. Pulls weight forward over one forearm at a time
(g) *Bilateral, Stage 21A Quadrupedal position.* Both arms and both legs extend
Unilateral Stage 21B Quadrupedal progression Both arms and both legs extend but move forward one at a time
(h) *Bilateral Stage 22 Standing.* Both arms and both legs extend
Unilateral: Stage 23 Walking. Arms and legs extend forward one at a time.

Four examples of the foregoing Bilateral-Unilateral shifts are illustrated by photodiagrams in Figure 2.

3 *Minor Trends*

Other trends mentioned in Table 1 require only brief mention, for they characterize only a few of the stages and do not, like flexion and extension, or bilaterality and unilaterality, involve the whole gamut of stages

a. Ipsilaterality vs. contralaterality Since arm behavior is mainly bilateral during the first seven stages and since leg behavior is relatively independent, we do not find arm and leg moving synchronously either on the same or opposite sides of the body. At Stages 8 and 9 arm and leg on opposite sides of the body frequently flex together. In Stages 10 and 15 behavior is largely ipsilateral, and in Stages 18 and following, again contralateral.

b. Abduction and adduction. These two movements may be regarded as special forms of flexion and extension Adduction is the more conspicuous trend noted throughout the whole ontogenetic sequence Legs are adducted in Stages 1, 6, 11*A*, 12, 14, 16, 18, 19, 20. A brief period of abduction occurs during Stages 4*B*, 7, 8, 9, and 10. This abductor trend closely coincides with the extensor era mentioned above in which extensor attitudes of leg and trunk prevail.

B. THE TOTAL DEVELOPMENTAL SWEEP

The nature of the developmental flow of prone behavior can be

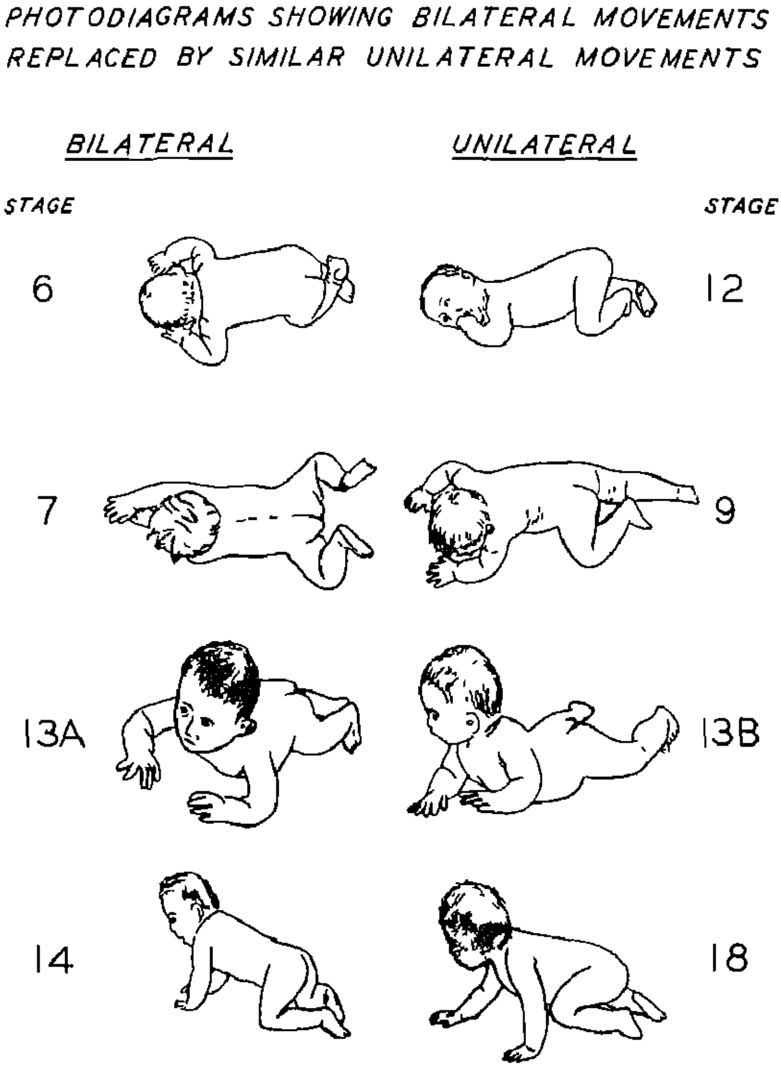
PHOTODIAGRAMS SHOWING BILATERAL MOVEMENTS REPLACED BY SIMILAR UNILATERAL MOVEMENTS
BILATERAL
UNILATERAL
STAGE
STAGE
6
12
7
9
13A
13B
14
18

FIGURE 2
PHOTODIAGRAMS TO SHOW BILATERAL-UNILATERAL SHIFTS OF BEHAVIOR

best appreciated when contemplated in its totality. The infant has four extremities. Viewed in ample perspective, the action patterns of these extremities do not assume a straight line seriation. The course of development turns on itself in a manner to suggest a spiral kind of neuro-motor organization When the movements of arms and legs are charted on a maturity grid, the significance of this "spiral" recurrence becomes apparent (Figure 3).

The infant's prone behavior progresses from an immature to a more mature state, but three or four times it partially reverts to a less mature state In the first 10 stages the infant advances from a primitive bilateral flexion of arms and legs to unilateral flexion of arms and legs, unilaterality signifying greater maturity. The trunk remains throughout in primordial contact with the ground surface. But in the last of these 10 stages (pivoting) the infant is able to use his extremities for circular locomotion and extrication. This terminates the first of four developmental cycles.

The second cycle entails the elevation of the trunk above its prostrate position. In accomplishing this new adjustment, the arms revert temporarily to their primitive posture of bilateral flexion, but the developmental patterning proceeds unabated even though in the crawling stage (Stage 13) the trunk relapses to a grovelling level By Stage 18 arms are extended bilaterally, legs are flexed bilaterally, and each pair of limbs moves alternately. This is classic creeping which all but terminates the ontogenetic sequence. Stages 19 and 20 are transitional to upright posture.

To achieve the exalted status of bipedal locomotion the developmental spiral takes two more short turns at ascending levels, constituting the third and fourth cycles. In both of these short cycles there is a partial reversion to immobile bilateral extension; namely in the plantigrade stance and in standing. Each cycle, however, culminates in locomotion, the third cycle in plantigrade progression, the fourth in walking

It takes the average human infant about 60 weeks to attain independent walking For a half-year he is virtually immobile in the prone position. Before he acquires the upright posture he exhibits a number of primitive and abortive modes of locomotion: rolling, pivoting, forward crawl, backward crawl, regression, rocking, creep-crawling, creeping, and cruising. The very diversity of these activities testifies to the complexity of the process of developmental pat

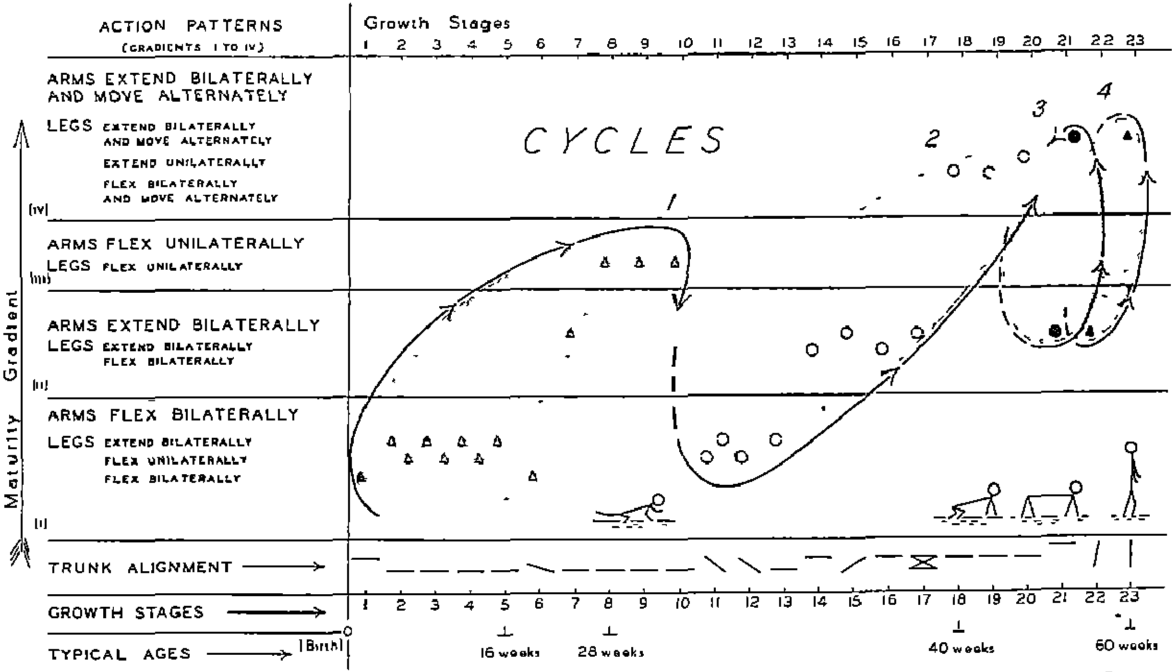

CHART TO SHOW GROWTH CYCLES IN THE PATTERNING OF PRONE BEHAVIOR

FIGURE 3

CHART TO SHOW GROWTH CYCLES IN THE PATTERNING OF PRONE BEHAVIOR terning. Some of the patterns have a recapitulatory suggestion, but they may be mainly regarded as functional expressions of transient but *necessary stages in the organization of the neuro-motor system.*

The general direction of this ontogenetic organization is unmistakably cephalo-caudal The infant can lift his head in the first week of life; not until the end of the first year does he stand on his feet. The expansion of neuro-motor coordination also proceeds in general from proximal to distal segments. Upper arm and upper leg come into postural integration before forearm, foreleg, hands and feet. The foot is both a caudal and distal terminus, the final fulcrum for locomotion.

Bilateral, unilateral, ipsilateral, contralateral members must be brought into parallel and diagonal coordination. It takes an enormous amount of dovetailing to structuralize these complicated relationships. Reciprocal neuro-motor interweaving is a mode of growth, a mode of ontogenetic organization, which determines the harmonization, the coordinate balance, and the functional asymmetries of muscle groups. The integrational operation of this principle of development is strongly evidenced in the patterning of prone progression (8).

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APPROACH AND WITHDRAWAL BEHAVIOR IN DOGS*

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These experiments were suggested by casual observation of wide variations in friendliness exhibited by the individual members of a group of 300 dogs studied at the Cornell University Experimental Morphology Station[1] Some dogs were completely friendly and would invariably seek human companionship, while other animals were extremely negative and withdrew on the approach of a person Many of the dogs were untame when first seen since they had not been handled or befriended, so a series of simple experiments were devised for taming the animals while roughly measuring quantitative changes in the positivity of their behavior.

An experimental group of 178 dogs, representing 14 pure-bred types and 19 hybrid mixtures derived through known heredity from the thoroughbred types, were studied. The dogs were lodged and fed in parallel concrete runways about 6 feet wide and 50 feet long. Some litters of 4-5 dogs occupied the same runway, but usually only two or three dogs chosen for their compatibility were quartered together. All the tests to be reported were performed with all the animals remaining in their own runways under conditions as normal as possible.

Three simple tests were adopted in which (*a*) the experimenter offered food through the wire fence without entering the run, (*b*) the experimenter entered the run and squatted in its entrance while offering food, and (*c*) the experimenter entered the run, and while standing, simultaneously offered food and attempted to pat the dog on the head. Quantitative scores were obtained by measuring the distance in feet of the closest point of approach of each animal to the experimenter in each of the three tests. An animal was judged completely friendly when he unflinchingly submitted to patting

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[1] Acknowledgment must be given to Dr Charles R Stockard for sponsoring and criticizing the investigation, and to Dr O D. Anderson who offered many suggestions during the actual experimental work.

in Test 3. The dogs were fed daily at 4 P.M., and the tests were carried out the next morning so that the animals were hungry and appreciative of the dog biscuit given as reward.

Each of the three tests was given daily to all dogs for 30 days. Table 1 presents data showing the progress in taming over this period. It is seen that the three test situations represent graded problems of increasing difficulty since it required more courage for the dog to approach when the experimenter was inside the run than when he was outside The percentage of dogs coming close enough to the experimenter to eat from his hand during the first five-day period was 77 per cent in Test 1, 64 per cent in Test 2, and only 49 per cent in Test 3. A month of thrice daily visits to the dogs resulted in an increase from 49 per cent to 76 per cent in animals friendly enough to eat from the hand in Test 3, however one in five of the 76 per cent still would not submit to patting. The greatest improvement in friendliness occurred during the first 10 days of the experiment, and after 20 days, practically every dog

TABLE 1

Showing for Each Five-Day Period During the 30-Day Experiment the Percentages of Animals in a Group of 178 Dogs Approaching to Within Certain Distances of the Experimenter in Three Tests of Friendliness

The 0 in the *Distances away* column indicates that the dogs came in contact with the experimenter *"Patted"* means that the dogs allowed themselves to be touched. Taming is shown by the higher percentages of dogs coming close to the experimenter in the later periods

	Distances away	Five-day periods (averages) 1	2	3	4	5	6
Test 1	0	77%	80%	81%	82%	84%	85%
	1 to 10 feet	13	10	11	13	9	10
	10 to 20 feet	6	4	1	2	4	2
	20 to 50 feet	4	6	7	3	3	3
Test 2	0	64%	71%	75%	78%	80%	79%
	1 to 10 feet	24	16	17	11	11	10
	10 to 20 feet	2	5	3	6	3	5
	20 to 50 feet	8	7	6	6	5	6
Test 3	Patted	40%	45%	51%	54%	55%	56%
	0	9	19	21	19	19	21
	1 to 10 feet	38	20	18	15	17	8
	10 to 20 feet	5	8	4	6	4	8
	20 to 50 feet	8	8	6	6	6	7

had demonstrated the maximum friendliness of which he was capable in this situation

The behavior of the less tame dogs warrants description for contrast with the friendly animal who met the experimenter with wagging tail, indicative of confidence The unfriendly animal approached with mincing steps, tail motionless and dragging, and with frequent retreats to safer ground. Some shy dogs sat 20-50 feet away from the entrance to the run and made no attempt to obtain the food, while others actually retreated to a point farther away on seeing the experimenter. The behavior of any dog was usually consistent, and did not appear to be influenced by imitation of other dogs In the shy dogs there seemed to be a balance between positive and negative factors which was easily upset by the slightest disturbance, resulting in momentary increases in negativity of the shy animals.

Since Test 3 was hardest for the shy dogs to face, the results from it have the most meaning and warrant further analysis. From Table 1, it is significant that improvement in friendliness occurred principally through taming of dogs originally approaching to within 10 feet at the beginning of the experiment The percentage of dogs remaining more than 10 feet from the observer is essentially the same at the end of the 30-day period as at the beginning This result is further demonstrated through individual rankings of the dogs according to the maximum degree of friendliness exhibited:

A—Dog completely friendly at all times
B—Eats from hand but cannot be touched.
C—Approaches to within 20 feet of experimenter
D—Dog remains 20 or more feet from experimenter

As noted in Table 2, 69 per cent of the dogs attained their highest ranking during the first five-day period, and 90 per cent by the 15th day, indicating that early ratings are reliable indicators of what the dog will eventually do

The tabulation of the number of dogs failing to attain *A* rating reveals 46 per cent of the dogs showing varying degrees of negativity which tended to persist At the start of the experiment, there were 17 very unfriendly animals and this group was augmented by the addition of 10 other animals who became more neurotic or unfriendly during the experiment, so that at the end

TABLE 2

Showing the Number of Dogs Receiving Their Maximum Rankings for Friendliness in Each Five-Day Period During the Experiment (70 Animals Received an *A* Rating During the First Period, While Three Did Not Achieve It Until the Sixth Period)

The starred numbers referred to animals which became neurotic or more unfriendly during the course of the experiment

Ranking	Five-day periods 1	2	3	4	5	6	Totals	%
A	70	7	11	4	1	3	96	54%
B	13	12	6	3	4	2	40	22
C	12	0	1	1	0	1	15	9
D	17	2*	1*	3*	1*	3*	27	15
Totals	122	19	18	8	5	6	178	
%	69	11	10	4	3	3		100%

there were 27 completely negative animals. It should be emphasized that the experimenter made special attempts to coax these negative animals to be friendly through extra attention and food. The distribution of dogs according to the degrees of friendliness, together with their constant maintenance of these rankings, suggests the existence of some factor underlying negativity which is relatively impervious to conditioning.

In an attempt to discover whether a more attractive reward than dog biscuit would cause some of the animals to become more friendly, raw juicy meat was substituted in another experiment using the three tests. The friendly animals accepted the meat with alacrity. The shy animals became paradoxically more negative, the meat seeming to excite them with a resultant heightening of the fear reaction. In no instance did meat overcome the shyness of a negative animal. That both meat and dog biscuit were acceptable to the negative animals is revealed in the fact that the food was immediately snapped up when the experimenter moved away.

A point of major interest regarding conditioned friendliness is that it appears to be specific to a given situation. It was observed that with tamed but timid animals, slight changes in the test procedure (such as wearing different apparel) were sufficient to cause the dog to revert to his original negative behavior until olfactory or other cues established the experimenter's identity. An experiment to test the transfer of tameness to individuals unknown to the dogs was carried out with four new observers who repeated the procedure originally completed by the author Unfortunately, the results from this transfer experiment are not strictly comparable to the author's results from Table 1, since the author had become known to the animals through preliminary experiments before the data were taken Summarizing the results from this experiment it may be stated that the 30-day taming period produced no appreciable difference in the attitudes taken by the shyer animals to newcomers. For all three tests, percentages of positive responses in the transfer experiment were consistently lower than the author's results at the beginning of the taming experiment In other words, the friendly responses built up toward the author did not produce any appreciable difference in the attitudes of the dogs to unfamiliar people.

The demonstration of a large group of dogs who could not be conditioned to become friendly through the use of passive methods suggested the use of force to overcome negativity. For various reasons, only 54 of the 82 shy animals remaining at the end of the taming experiment were available for further study Under conditions comparable to the taming experiment, the shy dogs were cornered and forcibly patted and handled whether they liked it or not

Three characteristic responses to the force technique developed in the dogs, which give considerable insight into the rôle of fear in negative behavior One group of dogs submitted to, and later sought the patting after they discovered that no harmful results followed No typical emotional disturbances were noted in this group The second group showed an inhibitory reaction in which they retreated to a far corner and then sat down shaking, refusing to eat although the saliva dripped from their jaws, vomiting occasionally, and usually urinating or defecating The emotion of fear appeared to paralyze them, and prevent any action The third group of dogs displayed an excitement characterized by restlessness, running about, and biting if touched

The degrees of fear in the various dogs was roughly estimated according to the following criteria·

I *No fear,* no incapacitation Dog eats. No vomiting, urination or defecation

II *Slight fear,* partial incapacitation Dog doesn't eat, or urinates while eating No vomiting or defecation

III. *Extreme fear,* incapacitation Dog defecates, urinates and vomits Doesn't eat

The responses of urination, defecation, and vomiting are roughly indicative, in the order named, of the degree of fear present in a dog. In addition to the fear response itself, the reaction of the animal to fear is important. An animal inhibited by fear presents a very different picture from the excited animal. The effect of daily forcing the dogs to submit to friendly overtures has been presented in Table 3. The effect of daily forcing the animals to submit to friendly patting resulted in an increase in friendly dogs from two to 20 in one month. Of this group, two dogs showed no fear the first time they were caught, 16 were first inhibited and later friendly, while only two animals belonging originally to Group 3 (excited animals) became friendly with this technique. It appears that an animal showing excitement is not accessible to stimuli productive of positive conditioning

TABLE 3

SHOWING THE REACTIONS MADE BY 54 SHY DOGS OVER A 30-DAY PERIOD OF BEING FORCED TO SUBMIT TO HANDLING

The cornered animals showed inhibitory reactions, while the excited animals ran back and forth and couldn't be touched The animals in Groups 2 and 3 are divided according to the degrees of fear shown Group 1 contains the animals that became friendly with this technique.

	Group 1 Patted animals	Group 2 Cornered animals			Group 3 Excited animals		
Degree of fear		I	II	III	I	II	III
1st day	2	10	18	8	1	10	5
5th day	7	4	23	3	1	10	5
10th day	13	7	14	3	0	11	6
15th day	17	4	15	1	2	3	12
20th day	19	4	14	1	2	3	11
25th day	20	4	8	2	2	6	12

The results *indicate that when an animal is excited, any attempt* to corner him exaggerates the excitement. Specifically, two of the dogs showing characteristic excitement became conditioned so that the behavior appeared whenever the experimenter appeared in the distance These dogs urinated, defecated, frothed at the mouth, snapped, bit, and hurled themselves at the fence in a frenzy of fear when they saw the experimenter coming. This behavior grew progressively worse. In dogs which were originally cornerable and inhibited, the patting occasionally appeared to become suddenly intolerable and a typical excitement developed. In these cases, a mild degree of fear produced the inhibitory behavior, while high degrees of fear changed inhibition into excitement Usually, however, the two types of behavior were distinct, and a dog that showed one would not show the other

Discussion

Statistical tables do not yield an adequate picture of the variations in friendliness in different dogs A study of individual graphs representing daily fluctuations in friendliness showed that positivity occurs as a gradient, and that there is a delicate balance between positive and negative reactions The more fearful the animal, the shyer he will be, and the more readily is his confidence disturbed with resulting inconsistencies in behavior Chance episodes tending to destroy the animal's confidence appeared to be more potent in producing negativity than are comparable influences inducing positive attitudes. This fact is demonstrated by an episode occurring with Dogs 59 and 61. At the start of the experiment, they never came closer than 2-3 feet away from the experimenter After three weeks, their confidence had been won to the point where they could be handled One day another animal in the run developed an ulcer on his abdomen and had to be caught and treated This procedure created some disturbance which so severely disturbed Dogs 59 and 61 that they never again voluntarily submitted to patting

The analysis of the genetic relationships between the shy dogs revealed a remarkable fact They were all related to other animals which had been known to be shy. Forty of the shyest animals were second, third, and fourth generation descendants of a single bitch who was known as a fear-biter. The question arises as to whether the negative behavior represented an innate tendency, or was the result of previous conditionings Although quantitative data are not available, observations on newborn litters suggest that the shyness and negative behavior may be noted soon after birth, and is not modified by conditionings. We have seen shy animals raised from birth with friendly animals without any change in their negativity. The behavior appears in spite of conditionings which should result in positive friendly behavior In several instances, deliberate attempts were made to produce conditioned fears or neuroses by frightening stimulation, but it only succeeded in shy animals. Animals that were originally friendly, remained so in spite of severe trauma.

SUMMARY AND CONCLUSIONS

Three simple tests were devised for measuring the friendliness of untamed dogs to an unknown person. An experimental group of 178 dogs was studied at the Cornell University Morphology Station. The dogs were rated according to the degree to which they became friendly during a 30-day period in which each animal was offered food three times daily. Although most dogs rapidly became friendly, about 25 per cent of the animals showed varying degrees of unfriendliness which was not modified by the taming. These animals showed a persistent fear response which was not altered by offering more attractive incentives to be friendly.

Conditioning in friendliness was demonstrated to be specific to the experimenter alone The animals were no more friendly to unknown persons at the end of the taming experiment than they were at the beginning.

The unfriendly dogs were subjected to another experiment in which they were caught and forced to submit to handling. A few dogs became friendly with this technique, but most animals fell into two types. One group of dogs became excited, and became increasingly refractory to any attempt to touch them. The other group appeared to be paralyzed by fear and submitted passively to the handling. Although two inhibited animals became excited when severely frightened, the two types of reaction were distinct.

Indirect observations suggest that the fear response underlying unfriendliness is hereditary, in the sense that the animal has an abnormally low threshold. Unfriendliness could not be produced by conditioning in animals who were initially friendly. Because of the large number of genetic strains which were studied, an analysis of the relationships between breed and neurotic tendency could not be made.

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THE EFFECTS OF INCOMPLETE CURARE PARALYSIS UPON FORMATION AND ELICITATION OF CONDITIONED RESPONSES IN CATS*

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A. PURPOSE

The purpose of the following investigation was to determine the effect of incomplete curare paralysis upon the formation and elicitation of conditioned reflexes in the cat Such a study is particularly pertinent since work by West indicates that curare causes perceptual disturbances in human beings. In one study on over 30 patients West (5) used doses of curare which *did not produce complete paralysis*, and he noted that . "giddiness was marked . . and (some of) these patients would describe their condition as being 'stupid' or 'fuddled' "

In a later study West (6) reports an extremely interesting case of partial paralysis induced by a 50 mgm dose of curarine (an alkaloid separated from crude curare). Paralysis was not complete as indicated by the following note, " . the arms were weakened but not paralyzed, the legs weak and relaxed but not entirely flaccid " At the same time marked sensory disturbances occurred, according to the subject's report of her experiences when in the drugged state.

> I didn't know when I was being touched I didn't feel the needle. I didn't know you were holding my wrist, it felt like a vice gripping it like ice When my sister put her hand on my forehead, I thought it was a lump of ice In one of my eyes, I saw a vision of my little girl very clearly When you said *"You're all right"* it was my husband's voice that I heard speaking The skin of my face felt drawn all tight

The above evidence indicates that curare acts as a cerebral depressant in man, even at dosage strength insufficient to cause complete paralysis

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**The author wishes to thank Drs Henry Settlage and Leonard Lovskin for assistance in planning and carrying out this investigation

B. METHOD

Eleven cats were used as subjects in the following investigation and a total of 16 tests were made.

Preparatory to testing the subjects were loosely fastened in a supine position to an animal board and were then placed inside a modified Drinker respirator[1] which could be used for artificial respiration when necessary.

The curare was injected slowly (1/5 cc per min. of a 1/2 per cent solution) into the femoral vein. There was no attempt to give arbitrarily predetermined quantities of the drug since equal doses gave inconstant results from day to day and from subject to subject. Observations of behavior changes and reflex responses during gradual intravenous administration made it possible to formulate a range scale of stages of paralysis, and slow induction of paralysis was continued in all tests in the experimental series until the desired stage had been reached. The behavioral and reflex signs corresponding to the five stages which were established are summarized in Table 1.

TABLE 1

Stage of curarization	Criteria
1	Respiration strong, reflex in all limbs normal, animal able to maintain posture
2	Respiration adequate, reflex responses to weak shock in limbs, difficulty in maintaining posture
3.	Respiration faulty (but artificial respiration unnecessary), limb reflexes to strong shock, inability to maintain posture.
4.	Artificial respiration essential, otherwise same as in Stage 3 above.
5.	"Complete" muscular paralysis, including abolition of pupillary reflexes to light and shock.

Those cats subjected to more than one drug dosage were tested initially on the highest dosage reported and tested later on dosages producing progressively less severe effects

Training for delayed conditioned responses was carried out in all cases by combining a bell (*CS*, 4 sec. duration) with an electric shock (*US*, 1 sec. duration). The *CS* was provided by an ordinary door bell placed about two feet from the subject's head; the *US* was a faradic current applied by means of an electrode fastened to the shaved surface of the subject's left front limb

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[1] Construction of the respiration was made possible by a grant from the National Research Council in 1932.

In each test, 10 *training* trials were given during the drugged state, with the *CS* (bell) being followed and reinforced by the *US* (shock) Even when conditioned responses appeared to the *CS* in the 3-second interval between initial presentation of *CS* and *US*, reinforcement by shock was always given These trials were conducted at intervals irregularly spaced around a 2-minute average

No additional training was given in any of the tests after the animals were judged to have recovered from the curare paralysis (as indicated by normal body posture and normal respiration) The *CS* (bell) was, however, presented five times *without* reinforcement by the *US* (shock) at the completion of every test

For subjects that had not responded positively to the *CS* in the drugged state but did respond positively to the *CS* in the normal state (without additional training) this served as a test of the capacity to elicit a response *latently* formed during the training period of the drugged state

C. Results

The data obtained in the first 14 tests of this experiment are presented in Table 2

The significant facts as found in this table are·

1 Escape responses were not conditioned even when skeletal muscle paralysis was far from complete Thus conditioned escape responses (as indicated by leg flexion or struggling) failed to appear at Stage 3 and appeared in only one out of five cases in Stage 2 in spite of the fact that unconditioned responses were obtained at both of these stages Indeed, in Stage 2, the cats were capable of initiating considerable voluntary movements

2. Conditioned pupillary reflexes proved more resistant to the effect of curare paralysis than did conditioned escape responses, as indicated by the fact that pupillary responses were formed at both Stages 3 and 4 of drug depression, whereas conditioned flight responses were never established at these stages. Furthermore, at Stage 2, pupillary responses were elicited both during and after the drugged state more frequently than were flight responses.

3. Both escape and pupillary conditioned responses were elicited

TABLE 2

INFLUENCES OF FIVE STAGES OF CURARE PARALYSISIS ON THE FORMATION AND ELICITATION OF CONDITIONED RESPONSES IN THE CAT

Exper No	Subject No	Est age	Dose mg/kg	Stage depression	Conditioning tests Escape responses				Pupillary responses			
					DC		AC		DC		AC	
					No CR	RS	No ER	RS	No CR	RS	No ER	RS
1	1	*M*	2.7	5	0	—	0	—	0	—	0	—
2	2	*M*	2.6	5	0	—	0	—	0	—	0	—
3	3	*M*	3.2	5	0	—	0	—	0	—	0	—
4	3	*M*	2.2	4	0	—	0	—	0	—	0	++
5	4	*M*	2.6	4	0	—	0	—	0	—	4	+++
6	5	*Y*	1.9	3	0	—	0	—	6	+++	5	+++
7	6	*Y*	1.6	3	0	—	0	—	0	—	3	++
8	4	*M*	1.5	3	0	—	0	—	0	—	0	—
9	7	*M*	2.2	2	6	+	5	+++	8	+++	4	++++
10	8	*Y*	0.9	2	0	—	5	++	0	—	5	+++
11	5	*Y*	1.7	2	0	—	4	+	7	++	5	+++
12	3	*M*	2.2	2	0	—	0	—	5	+	3	+
13	9	*M*	4.8	2	0	—	0	—	0	—	2	+
14	3	*M*	2.0	1	8	++	3	+	3	+	3	+

Interpretation *Under age* Y = young, *M* = mature *Under conditioning tests* *DC* = tests for conditioned responses made during curarization, *AC* = tests in the normal state for elicitation of conditioned responses which had been formed in the drug state (note that *no training* was given during this normal state period), *No CR* = number of observed conditioned responses during 10 training trials, *No ER* = number of responses elicited in five presentations of the *CS* not reinforced by the *US*, *RS* = maximum response strength *Under RS* — (minus sign) = no response + signs) = relative strength of the conditioned responses rated by the number of pluses (+ = weak response, ++++ = very strong response) with greater frequency *after* recovery from incomplete curare paralysis than *during* incomplete curare paralysis Thus in all tests in which conditioned responses were elicited during partial paralysis, the same conditioned responses were elicited during recovery Six cases, however, are recorded in which conditioned responses were elicited after recovery from curare paralysis in spite of the fact that they had not appeared in the training period given during the drugged state (two cases concern conditioned escape responses, four cases concern conditioned pupillary responses) It should be particularly emphasized that the greater frequency of conditioned response elicitation in the normal state cannot be explained on the basis of additional training since *no training was given in the normal state.* The five test presentations of the *CS* (bell) in the normal state were *never reinforced* by the unconditioned stimulus

As a further check on the action of curare as a cerebral depressant, Tests 15 and 16 were carried out on Subjects 10 and 11, respectively These subjects weighing slightly more than two kilograms each, were injected with 0 7 cc. of the ½ per cent solution and reached Stage 2 of curarization. Conditioned escape responses were elicited in 7 out of 10 training trials in Subject 10 and in 8 out of 10 training trials in Subject 11 In Subject 10, with an additional 0 1 cc of the curare solution all overt conditioned responses disappeared and in Subject 11, an additional 0 2 cc accomplished the same result In these cats, *the elicitation of the learned response was abolished by a drug dosage which did not abolish voluntary or reflex movements and which had produced no serious alterations in normal postural tone*

D DISCUSSION

Comparison of the data obtained from different experiments on curarized animals is made difficult by the fact that every sample of curare produces different physiological effects The author has carried out four experiments using five different samples of curare. Each sample gave different results, the worst (not reported) gave almost 100 per cent fatalities, the best (reported by Harlow and Stagner) permitted strong conditioned and unconditioned pupillary responses even during "complete" skeletal muscle paralysis A similar variability, both in nature and range, has been reported by West (5, 6) using both samples of curare and curarine on lower animals and on human beings.

In spite of the difficulties occasioned by variability in the drug samples, the experiments on curare indicate certain general conclusions discussed below.

1. *Curare is a cerebral depressant.* It is of the utmost importance in interpreting the data obtained during curare poisoning to ascertain the loci of action of the drug. It has long been known that curare (or one or more of its constituent alkaloids) seriously interferes with the passage of impulses from the somatic efferent nerves to the skeletal muscles.

However, data presented by Girden and Culler (1) and by West (6) prove that some skeletal muscle responses are possible even when curarization is carried to the stage of respiratory failure. As expressed by Girden and Culler:

> Curare exhibits a kind of "hobble-effect"—the muscle can react "thus far and no further," whatever magnitude of stimulus is employed; but its response to liminal or near liminal stimuli is but little effected

There is now ample evidence to prove that curare depresses the central nervous system, even at doses which do not cause complete skeletal muscle paralysis. We have already mentioned the fact that West's (6) data supported this position. Confirmatory evidence is presented in this paper which shows that learning is impossible in cats even at stages of curare depression that have not seriously effected motor control. Girden and Culler also express the idea that curare depresses the central nervous system and state that "we seem to have some depression between cortex and spinal root" and that "the animal under curare is functionally decorticate. . . "

The data recently presented by Harlow and Settlage (2), which demonstrated that retention of conditioned responses might continue for a short period of time after curarization of the forepart of the body, may be explained by assuming that the time involved is that taken by the drug to bring about cerebral depression.

2 *Curare produces different influences upon the various components of a total conditioned response pattern.* So far (3, 1) the effect of curare has been studied on three conditioned responses: conditioned escape responses, conditioned pupillary responses, and conditioned responses of the isolated semitendinosus muscle. Actually, each of these three conditioned responses is a component of a complicated conditioned response, the conditioned emergency-flight response.

Data from the various curare experiments show that the conditioning of each of these components of the emergency-flight response is probably susceptible to the depressive action of curare to a different degree. Thus the experiments by Harlow and Stagner (3) and by Harlow (this paper) show that conditioned pupillary (smooth muscle) responses may be established during a stage of cerebral depression that makes impossible the formation of conditioned escape responses involving gross responses of the skeletal musculature. Furthermore, Girden and Culler have demonstrated the formation of conditioned responses in the isolated semitendinosus muscle during "complete" curare paralysis, a stage of paralysis at which conditioned escape responses (involving skeletal muscles) cannot be formed.

That other drugs also have differential effects on the conditioning of various components of the response to electric shock is indicated by the work of Settlage (4), who found that doses of sodium amytal more seriously affected the conditioning of leg flexion than pupillary dilation.

These data show that relatively complex conditioned responses which act as functional units are susceptible to fragmentation. Thus, under drug states a total pattern of a conditioned response may disappear, although the *CS* will still elicit one or more of its component responses. The components themselves are, of course, likely to be affected to a varying degree.

3. *Curare may exert differential effects on the processes involved in the formation and elicitation of conditioned responses.* The data of the present paper show that conditioned escape and pupillary responses may be latently formed under stages of curarization that block response elicitation. Thus, in six cases reported in Table 1 no conditioned responses were elicited during the 10 training trials carried out in the drugged state. Conditioned reflexes must have been latently formed at that time since they were elicited upon recovery without additional training, i.e., the *CS* was presented but never the *US* after recovery from curare. The same observation had previously been reported by Settlage (4) who studied the effect of sodium amytal on the conditioned leg withdrawal response in the cat. The above data are all in keeping with Settlage's conclusion, "that processes involved in the formation and in the elicitation of conditioned responses are differently effected by the use of

given quantities of drug" and suggest that elicitation of the conditioned responses is more susceptible to drugs than is the formation of the learned reaction.

Girden and Culler (1) have demonstrated that responses in isolated semitendinosus muscle conditioned when the dog was in a particular physiological state (either normal or curare depressed) could only be elicited when the subject was in the same state. Thus responses conditioned under curare could not be elicited in the normal state but reappeared upon curarization. Likewise, ". . . a conditioned reaction established in the normal state vanished under curare but reappears unimpaired after recovery from the drug."

Though both Girden and Culler and the present author obtained evidence that curare may exert differential effects on the processes involved in the formation and in the elicitation of conditioned responses, the phenomena reported are in certain respects divergent.

In the experiments of Girden and Culler, an already formed conditioned response disappears with a change of subject from drugged to normal state, or vice versa. In the experiments of the writer, a conditioned response whose existence is not evident under the drugged state, appeared for the first time in the normal state.

4. *All demonstrated loss of learning capacity occurring during curare paralysis can be explained as the result of central depression.* Harlow and Stagner (3) attempted to condition cats and dogs under "complete" curare paralysis (light or bell as *CS*, shock as *US*). Conditioned pupillary responses appeared during the drugged state, but there was no evidence of the formation of conditioned skeletal muscle responses; i.e., *retention tests* made after recovery from the drug did not elicit conditioned skeletal muscle responses. On the basis of these observations Harlow and Stagner concluded that "conditioned reflexes are only possible if a response is made, and do not result merely from stimuli presented simultaneously."

Experiments conducted by Harlow (this paper) on curare and by Settlage (4) on sodium amytal show that neural mechanisms controlling pupillary conditioned responses are less susceptible to drug effects than those controlling conditioned skeletal muscle responses of the total body. Thus Harlow and Stagner's earlier assumption that the integrity of pupillary conditioned responses indicated that the central nervous system was not depressed is no longer tenable. Furthermore, it is possible that the difference in the results observed in the two motor systems resulted from the fact that the conditioned pupillary responses *could be observed during the drugged state,* whereas the skeletal muscle responses could only be *tested after recovery.* Since Girden and Culler (1) found that conditioned responses of the isolated semitendinosis muscle could be formed during the drugged state but could not be elicited after recovery, it is possible that skeletal muscle responses were conditioned in Harlow and Stagner's subjects but that this conditioning could not be demonstrated in the normal state.

West (6), Girden and Culler (1), and the present writer have all presented evidence proving that curare depresses the central nervous system, and any loss of learning capacity so far reported may be explained on this assumption.

All available evidence seems now to indicate that learning is possible under practically complete skeletal muscle paralysis. Girden and Culler (1) obtained conditioned responses in isolated semitendinosis muscle after all normal body posture had been completely abolished by curare paralysis, and Harlow and Stagner (3) obtained conditioned pupillary responses under similar circumstances. Neither of these experiments bear on the rôle of the body posture upon the more complex learning situations but clearly indicate that the normal muscle tonus is not essential to all learning. Thus the data from the curare experiments cannot be used to support the motor theory of learning, and clearly refute such a theory if it is to be applied to all learning phenomena.

E. SUMMARY AND CONCLUSIONS

Sixteen experiments carried out on 11 cats on the effects of incomplete curare paralysis on learning gave the following results.

1. Conditioning of a complex skeletal muscle response (flight response) becomes impossible in curarization even before bodily paralysis is complete. Apparently the central nervous system is seriously depressed by curare in doses insufficient to cause total paralysis of the skeletal muscles.

2. Conditioned pupillary responses are formed during states of curare paralysis in which conditioned flight responses cannot be established. Evidently the central mechanisms controlling the formation of the conditioned pupillary responses are less susceptible to central depression of curare origin than are those of the flight response.

3. In certain cases conditioned pupillary and flight responses are latently formed during the drug period but cannot be elicited until after recovery.

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SOLUTION OF PATTERNED STRING PROBLEMS BY MONKEYS*[1]

Columbia University, Essex Junior College, and the Research Council for Blind Children

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The aim of the present experiment was to determine the ability of monkeys to solve a graded series of patterned string tests similar to those recently used on children The literature to date covering tests of this sort has been adequately reviewed by Kluver (3), Richardson (5), and by Harlow and Settlage (2). These reviewers have included as well the performance of various subprimate mammals On the whole, it has been found that monkeys are greatly superior to the latter, as might be expected

A. Method and Procedure

The 10 monkeys used in this investigation may be classified as follows two spiders (*Ateles geoffroyi*), two common cebus (*Cebus capucina*), one weeper capuchin (*Cebus apella*) and five rhesus (*Macaca mulatta*). Certain characteristics of the several animals are indicated in Table 1 The spider monkeys and the weeper capuchin, Trader, were supplied by Dr. C R Carpenter and were probably about five years old The common cebus types and the rhesus monkeys were secured from local dealers and were two and one-half to three years old when purchased

The animals were housed in the primate vivarium of the Columbia University animal laboratory for several months before the tests were begun During this time they were exercised daily by the keeper and tamed by the two experimenters They were fed the standard diet used in this laboratory (1, 4), which is well balanced for vitamins, and were exposed to a General Electric sunlamp for 15 minutes

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[1] This report covers one topic in a project on Intelligence in Monkeys (under the direction of Professor C J Warden), supported by the Council for Research in the Social Sciences of Columbia University.

[2] The general method employed was devised by the authors in collaboration The junior authors carried out the tests and tabulated the data, and the senior author wrote the final report

TABLE 1

CLASSIFICATION OF MONKEYS

Monkey	Sex	Behavioral characteristics
Spider 1	*F.*	Very tame but somewhat timid, worked well after preliminary adjustment
Spider 2	*M.*	Tame but somewhat aggressive, used tail instead of hand at the beginning
Cebus 1	*M*	Tame but somewhat cautious at first, soon became good subject.
Cebus 2	*M*	Tame and well adjusted to the situation
Trader	*M.*	Extremely vigorous and persistent in working at the problems, well adjusted.
Rhesus 1	*F*	Somewhat cautious and easily discouraged when no progress was being made
Rhesus 2	*M*	Very timid and worked well only when problems were easy
Rhesus 3	*F*	Tame and somewhat aggressive
Rhesus 4	*F.*	Somewhat cautious, good subject
Rhesus 5	*M*	Very tame and tractable, excellent subject

daily. The two spider monkeys died rather suddenly from a latent tropical disease soon after the testing period began. The other animals were maintained in good health throughout the experiment.

B. APPARATUS

The apparatus for testing the animals consisted of a cage and a working platform. The cage was 30 inches in all dimensions, with vertical bars across the front approximately an inch and a half apart, and was painted white inside. The platform was also white and extended 30 in. forward from the barred front. The cage was lighted by three Mazda bulbs (40-watt) and the platform by a reflector carrying a 200-watt bulb. No other lights were present in the dark room in which the tests were made. The experimenter stood behind a silk gauze screen placed parallel to the platform. The various patterns of strings were placed on the platform directly in front of the animal. A 16-inch Westinghouse fan was run at low speed to serve as a sound screen during the tests.

C. PROCEDURE

Each animal was led by means of a short leash from the vivarium to the adjacent test room and placed in the lighted cage. The setting of strings was arranged, the cage lights turned off, and the sliding panel covering the barred front of the cage was raised. After the animal had reacted, other settings were made in a similar manner. Time was taken with a stop-watch, and errors were recorded and classified according to the position of the strings in the pattern. The food cup containing the incentive was one and three-quarters inches in diameter and one-half inch in depth. The incentive used was one raisin or one-quarter kernel of peanut, according to the preference of the animal. As a rule about five trials were given at a session. The tests were made during the forenoon before the heavy or midday meal, and about two hours after a breakfast of milk and eggs (7 A.M.). The animals appeared to be well motivated throughout the tests. They were adjusted to the cage, with the sliding panel raised, by getting the incentive in this situation for some days before the tests began.

D. RESULTS

The series of tests were given in the following order: (*a*) pulling in a single string, (*b*) parallel strings with right and left positions constant, and (*c*) the series of multiple strings illustrated in Figure 1, with right and left positions varied in an irregular order.

1. *Single String*

This task consisted merely in drawing in the string with food cup attached and securing the incentive. The proximal end of the string was placed three inches from the barred front of the cage for all, except the spider monkeys, the distance being five inches for these on account of their longer arm. The direction of the string on the platform varied from the median position to oblique positions left and right. These variations were introduced in order to familiarize the animal with positions to be used in later patterns. This task offered very little difficulty to any of the animals. The spider monkeys failed a few times (3-minute limit) because they persisted in trying to seize the food cup with their long prehensile tail. This habit was broken up by touching the tail with a small stick, which caused a withdrawal reaction, whenever the tail was extended through the bars. The other monkeys tried to reach the food cup directly with the arm, but after a few unsuccessful attempts this response was abandoned. Almost from the beginning, most of the animals grasped the string as soon as the panel was raised. Twenty trials were allowed, however, in order to make this

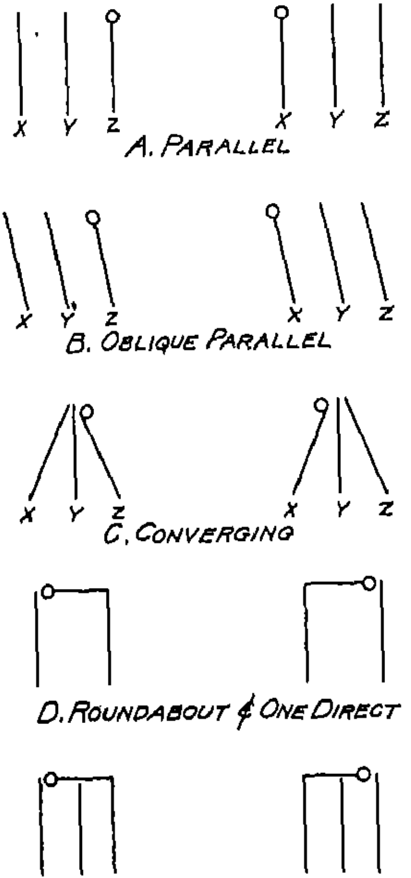

FIGURE 1

MULTIPLE STRING PATTERNS SHOWING RIGHT AND LEFT SETS OF THE SERIES OF PATTERNS EMPLOYED

response direct and automatic. The average time per trial for the last half of this series was as follows: spiders 1.7 seconds, cebus 0 8 seconds, rhesus 3.95 seconds. It appears, therefore, that the response of pulling in an object of this sort is a natural reaction of the monkey and requires little or no practice to perfect.

2 *Parallel Strings Positions Constant*

This task consisted in selecting the proper one of three strings arranged as in Pattern *A* (Figure 1) The habit of selecting the string placed to the right was mastered before training was begun on selecting the string placed to the left of the pattern As will be noted (Figure 1), the strings are labeled *x*, *y*, *z*, from left to right in this pattern When the correct string is to the right of the pattern, *x* and *y* are the possible errors When the correct string is to the left of the pattern, then *y* and *z* are the possible errors The results covering the first 10 trials of both settings are given in Table 2 The strings were placed three inches from the bars for the rhesus and cebus monkeys and five inches for the spider monkeys The strings were parallel and spaced two inches apart. They were eight inches in length for the cebus and rhesus monkeys and 10 inches for the spider monkeys

As will be seen, the task of learning to pull in the right string of the pattern was readily learned by most animals. In fact the norm of two perfect out of three trials, or better, was reached by all of the animals by the end of the 10th trial Two of the animals made only a single error each during the 10 trial series. The shift to the left string of the pattern caused the error score to rise for a few subjects, but in most cases the change involved little difficulty. The average time per trial was more uniform in the second series, indicating that the response had become more specific and automatic The few animals that had not mastered the patterns in 10 trials were given additional training before being advanced to more difficult tasks. The data of Table 2 offer no basis for concluding that one species is better than another on this type of task The differences in time and error scores do not consistently favor one species as against another The high time scores of three of the rhesus monkeys on the right pattern are due to failure (3-minute limit) on the first few trials These animals did no worse than the average on the left pattern.

3. *Multiple String Patterns Graded Series*

After the completion of the above tests, work was begun on the series of patterns indicated in Figure 1. While this is not a perfectly graded series, it is fairly obvious that the steps become progres-

TABLE 2

RESULTS ON PARALLEL STRING PATTERN WITH RIGHT AND LEFT POSITION CONSTANT (10 TRIALS)

	Right position					Left position				
		Errors					Errors			
Animal	Average seconds per trial	x	y	Total	Total perfect trials	Average seconds per trial	y	z	total	Total perfect trials
Spider 1	1.1	0	4	4	6	1.8	3	3	6	7
Spider 2	0.9	0	1	1	9	1.1	0	0	0	10
Cebus 1	6.4	3	5	8	5	4.8	5	7	12	3
Cebus 2	1.7	3	6	9	3	2.5	7	7	14	3
Rhesus 1	21.6	0	1	1	9	3.8	9	9	18	1
Rhesus 2	1.7	0	5	5	5	3.5	10	10	20	0
Rhesus 3*	1.6	2	3	5	6					
Rhesus 4	44.8	4	4	8	3	1.5	2	3	5	7
Rhesus 5	13.3	0	2	2	8	3.8	8	5	13	2

*Rhesus 3 was not tested on the left position set

TABLE 3

SUMMARY OF RESULTS ON PROBLEMS *A*, *B* AND *C* (FIGURE 1)

	Problem *A* (parallel)						Problem *B* (oblique parallel)						Problem *C* (converging)					
		Average seconds		Errors				Average seconds		Errors				Average seconds		Errors		
Animal	Total trials	per trial	x	y	z	Total	Total trials	per trial	x	y	z	Total	Total trials	per trial	x	y	z	Total
Spider 1	0	0	0	0	0	0	9	1 77	1	6	5	12	4	1 50	0	2	0	2
Spider 2	0	0	0	0	0	0	3	2 00	1	1	0	2	17	2 88	2	15	5	22
Cebus 1	0	0	0	0	0	0	1	5.00	0	1	0	1	15	6 90	0	11	5	16
Cebus 2	0	0	0	0	0	0	6	1 00	0	3	0	3	0	0	0	0	0	0
Trader	0	0	0	0	0	0	31	1 39	5	10	0	15	0	0	0	0	0	0
Rhesus 1	1	1 25	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Rhesus 2	0	0	0	0	0	0	0	0	0	0	0	0	4	0 63	1	1	0	2
Rhesus 3	1	2 0	0	1	0	1	10	1.10	0	3	1	4	30	1 35	1	21	9	31
Rhesus 4	0	0	0	0	0	0	0	0	0	0	0	0	60	1 68	15	29	4	48
Rhesus 5	0	0	0	0	0	0	0	0	0	0	0	0	40	1 04	0	16	15	31

The zero scores for trials indicate that the animal met the norm of four perfect trials out of five without practice

The zero time scores indicate that the animal reacted so rapidly that accurate stop-watch records could not be taken sively more difficult The data secured do not indicate the relative difficulty of the several steps, since possible transfer-interference effects may have run through the series as a whole It will be convenient to group the results as follows (*a*) Problem A (*parallel*), *B* (*oblique parallel*), and *C* (*converging*); (*b*) Problems *D* and *E* (*roundabout-direct*). These will be discussed in order. It should be noted that the scores given in all the tables that follow are based on the trials up to but not including the norm.

a. Problems A, B, and C These were similar in certain respects For example, each pattern consisted of three strings 10 inches in length and spaced four inches apart at the proximal end. Pattern *C* differed from the other two in that the spacing at the point of convergence was three-sixteenths inches, and hence required more accurate discrimination. The correct string in each of the three patterns was varied in the right and left position in an irregular order. The results for these three problems are given in Table 3

In a sense, Problem *A* was a repetition of the preceding task reported above The patterns were exactly the same. The only difference in the two set-ups was, as previously tested, the right and left positions of the correct string was not varied from trial to trial. It seemed best, therefore, to repeat the test, varying this factor in random order A reference to the first section of Table 3 will show that this change in procedure did not disturb the response measurably. In fact, eight of the 10 animals met the norm of four perfect trials out of five without any further practice whatsoever, and the other two animals made only a single error each on the first trial.

The pattern in Problem *B* was similar to that of *A*, except that the strings lay at an oblique angle with respect to the subjects. Apparently this factor increased somewhat the difficulty of discrimination. Nevertheless, four animals met the norm of four perfect trials out of five without practice. If an exception be made of *Trader*, the number of trials for the other animals ranged from one to 10.

Problem *C* was more difficult than the other two, since the distance between the strings at the point of convergence was only three-sixteenths of an inch. Nevertheless, three animals met the norm of four perfect trials out of five without practice. Rhesus No. 4 failed to solve the problem after 60 trials, but was immediately successful when the distance between the strings was increased to three-eighths inches.

A glance at Table 3 will indicate that individual animals showed little consistency through this series of problems. For example, *Trader*, who made the worst record on Problem *B* made a perfect score on Problem C, whereas rhesus No 4 made a perfect record on Problems *A* and *B* but failed Problem *C*. Moreover, the animals of one species were not consistently better than those of another when the series is taken as a whole

b. *Problems D and E* The patterns used in these two problems were similar in that the correct string was "roundabout" in each case Problem *E* was more difficult, however, since the pattern involved two direct strings instead of one, as shown in Figure 1

In Problem *D*, the direct string was 10 inches long The string to which the food cup was attached was enough longer than this to allow a space of 6 5 inches between the two strings plus the gap between the food cup and the direct string This gap varied from three-sixteenths inches as in Figure 1 to three inches in width during various stages of the test The animals were first tested with the gap set at three-sixteenths inches except for rhesus No 4 (see footnote, Table 4) If an animal failed to reach a norm of four perfect out of five trials within a 30-trial series, the gap was widened to three-eighths inches If the norm was not reached at this easier level, after a series of 10 trials, the gap was increased to three-fourths inches The gap was doubled thereafter at failure on each 10-trial series up to three inches if necessary In most cases, when the animal met the norm at a wide gap, it was re-tested on gaps of lesser width in the series until it failed at some point. In this way the gap limit of each animal was determined, as indicated in Table 4. This limit may be regarded as an index of perceptual ability, under the special conditions here employed

The spider monkeys responded correctly within a few trials when the gap was only three-sixteenths inches wide Two of the three cebus monkeys reached this level after considerable training, whereas the other failed when the gap was three-eighths inches wide The rhesus monkeys made a poor record on this problem even after they had been given extensive training, as indicated in Table 4. None of this group was able to reach the gap limit of three-sixteenths inches, and only two of the five animals reached the three-eighths inch limit. The gap limit for the other three rhesus monkeys extended beyond that width up to three inches. This evidence would seem to suggest that the perceptual acuity of the rhesus monkey is lower than that of the other two types. The difference may have been due in part to factors of attitude and attention. In problems of this sort rhesus monkeys are more easily distracted than the other two types Their movements are also less deliberate and more fitful

The pattern in Problem *E* was similar to that in Problem *D*, except for the presence of a middle direct string (Figure 1). The latter was always placed approximately three and one-quarter inches from the parallel segment of the longer string. The gap between the food cup and the outer direct string varied from three-sixteenths inches, as drawn in Figure 1, to three inches The procedure for determining the gap limit here was in general the same as that used in Problem *D*. However, the gap limit determined for each animal on Problem *D* was taken as the first step in the present series

The results of this problem are given in Table 5 As already noted, the spider monkeys had both died before this test was begun This problem proved to be markedly more difficult than the previous one, since all animals required considerable training. Moreover, the gap limit finally reached was wider in the case of most animals. The difference between the cebus and rhesus monkeys seems to be less clearly marked than on Problem *D*. In fact, the gap limit for two of the rhesus monkeys was lower than it had been on the previous problem This was probably due to further perceptual training involved in the present test. However, the cebus monkeys made a much better record, in terms of gap limit, than the other three rhesus. The limits of the latter were either the same or higher than those obtained in Problem *D*.

E SUMMARY AND CONCLUSIONS

The present report covers a series of tests demonstrating the ability of spider, cebus, and rhesus monkeys to solve patterned string problems. The results suggest that rhesus monkeys are inferior to the other two types in this kind of test. Further work will be necessary, however, before a definite conclusion can be drawn

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INSTRUMENTATION IN CEBUS AND RHESUS MONKEYS*[1]

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Little systematic work has been reported, up to the present, on instrumentation in primates By far the greater part of such work has been limited to the great apes A review of the studies on the latter group will be found in the volume by Yerkes and Yerkes (7) A recent systematic study by Jackson on the chimpanzee has not been published as yet The work on monkeys has been recently summarized by Kluver (2), Fjeld (1), and Warden, Jenkins, and Warner (5) An examination of the literature will indicate clearly that the work on monkeys has been more or less exploratory In a recent study by the present authors (6) a systematic study of the ability of several types of monkeys to solve patterned string problems has been reported. This type of task, involving the selection and drawing in of a string attached to a food cup, proved relatively easy for spider, cebus, and rhesus monkeys The present problem may be regarded as an extension of this study to the use of rakes or T-sticks As a matter of fact, the animals used in the latter experiment were carried over from the earlier experiment on strings

A. Subjects

The eight monkeys used in this investigation may be classified as follows two common cebus (*Cebus capucina*), one weeper capuchin (*Cebus apella*), and five rhesus (*Macaca mulatta*) The weeper capuchin (Trader) was supplied by Dr C R Carpenter The other cebus and the rhesus monkeys were secured from local dealers and were three to three and one-half years old when tested

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[1] This report covers one topic in a project on Intelligence in Monkeys (under the direction of Professor C J Warden), supported by the Council for Research in the Social Sciences of Columbia University

[2] The general method employed was devised by the authors in collaboration The junior authors carried out the tests and tabulated the data, and the senior author wrote the final report

The animals were housed in the primate vivarium of the Columbia University animal laboratory for several months before the tests were begun During this time, they were exercised daily by the keeper and tamed by the two experimenters Moreover, all of the animals had been used for approximately three months in connection with the string problems noted above They were fed the standard diet used in this laboratory (1), which is well balanced for vitamins, and were exposed to a General Electric sunlamp for 15 minutes daily. The animals were maintained in good health throughout the experimental period, which began about April 15, 1936, and ended about June 15, 1937 The sex, weight, and certain behavior characteristics of the monkeys are listed in Table 1.

TABLE 1
CHARACTERISTICS OF MONKEYS

Monkey	Sex	Weight (oz.)	Behavioral characteristics
Cebus 1	*M.*	44	Somewhat cautious but worked well; some chattering and scolding when problems were difficult, but persistent
Cebus 2	*M*	50	Vigorous in movements, well adjusted, and very persistent Chattering and scolding when problems were difficult
Trader	*M*		Very tractable, extremely vigorous and persistent in attacking the problem
Rhesus 1	*F*	112	Good subject but somewhat cautious and easily discouraged
Rhesus 3	*F.*	98	Somewhat aggressive, vigorous movements, worked persistently but often very carelessly.
Rhesus 4	*F.*	100	Good subject, fairly persistent

B. APPARATUS

The apparatus for testing the animals consisted of a cage and working platform. The cage was 30 inches in all dimensions, with vertical bars across the front approximately an inch and a half apart, and was painted white inside. The platform was also white and extended 30 inches forward from the barred front The series of rakes were arranged for the animal by means of the serial ledge device, as illustrated in Figure 1. As will be seen, each narrow ledge (2.5 inches wide) was notched at both ends so as to provide an inset for the cross-bar of the rake A given series of rakes could thus be presented to the animal in perfect alignment at slightly rising

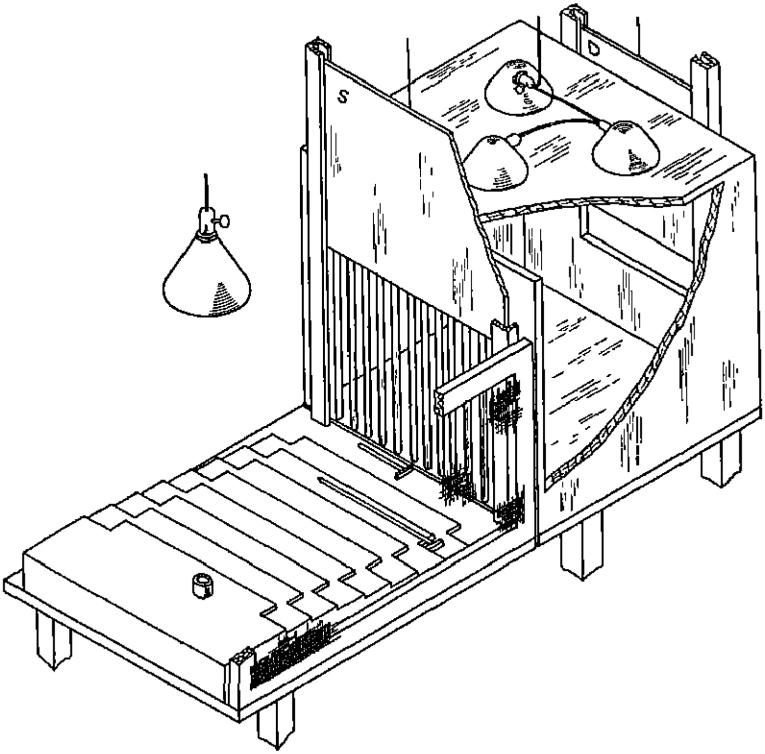

FIGURE 1

The Apparatus

S, shutter used to control exposure of rakes, *D*, door in back of reaction cage for admitting animal

levels Doubtless, this arrangement decreased the mechanical difficulty of drawing in the rakes when the proper order and pattern of movement was used. The latter factors were also emphasized by the use of the rakes (T-sticks) instead of plain sticks The cage was lighted by three Mazda bulbs (40-watt) and the platform by a reflector carrying a 200-watt bulb No other lights were present in the dark room in which the tests were made The experimenter stood behind a silk gauze screen placed parallel to the platform. A 16-inch Westinghouse fan was run at low speed to serve as a sound screen during the tests

TABLE 2

SHOWING LENGTH IN INCHES OF THE SEVERAL RAKES USED IN THE SERIES OF STEPS BY THE VARIOUS TYPES OF MONKEYS

	Cebus Monkeys 1, 2
Step I	12
II.	7.5—12
III.	7.5—10—14
IV	7.5—10—13—16 (Cebus No. 2, 14—18)
V.	7.5—10—14—18—22
VII	7.5—10—13—16—19—22—25
VIII	7.5—10—13—16—19—22—25—28
	Rhesus Monkeys 1-5, *Trader*
Step I	14
II	12—18 (Trader, 16)
III	8—14—20
IV	8—14—20—26
V.	9—13—17—21—25
VII.	9—12—15—18—21—24—27
VIII	9—12—15—18—21—24—27—33 (Trader, 32)

Note. Step VI was omitted from the series for all animals in order to extend the series as far as possible within the allotted time.

The series of rakes used in the tests are listed in Table 2. In Step 1 (Single-rake test) a fairly long rake was used, the exact length depending on the size and arm length of the species. In later steps, the earlier rakes in the series were shortened as much as possible so that the final instrument would not be too long and unwieldy. The cross-bars varied from two to three inches in length, depending on the length and diameter of the handle. The handles were made of round ash doweling and varied from five-sixteenths to eight-sixteenths inches in diameter. As a rule, the diameter of the longer sticks was gradually reduced so as to keep the weight of the rake as low as possible.

C. PROCEDURE

As a rule, the tests were given in two periods, of 10 trials each, in the morning and afternoon. The first period occurred several hours after a liquid breakfast (milk and eggs), and the last period before the animals were given the heavy meal of the day. The animals were, therefore, always reasonably hungry when tested. The incentive was usually one-fourth peanut kernel and one small raisin, which were placed in the food cup together. In some of the more difficult series motivation was increased by giving the animal onesixteenth to one-fourth of a banana on certain trials So far as could be observed, a high degree of motivation was maintained throughout the experiment. The common cebus monkeys were carried from the living cage and placed in the apparatus, while *Trader* and the rhesus monkeys were brought in by means of a transfer cage (4)

The tests were carried out under dark-room conditions, except for the lighting of the cage and platform, as indicated above A one-way light screen, made of silk gauze, stood between the experimenter and the apparatus. In setting the apparatus for a given trial, the lights were turned on, the food cup baited, the series of rakes arranged, and the shutter closed. After the animal had been placed in the test cage, the shutter was raised and the stop-watch started The shutter was closed at the completion of the trial and the time records recorded The general procedure here described was followed in connection with both problems of the experiment (*a*) Single-rake problem, and (*b*) Multiple-rake problem. Minor differences in technique and scoring will be indicated in the separate treatment of these problems

1 *Single-Rake Problem*

The first task was to train the animals to use a single rake as an instrument, regardless of its position on the platform. The series of steps involved is roughly indicated by the set of rake positions shown in Figure 2. As will be seen, the task at Position *A* was merely to draw in the rake, since the bar already lay behind the food cup The *B* and *C* positions required some actual manipulation. At Position *B*, for example, the rake had to be moved to one side before it was pulled in Position *C* required a movement of the rake back and to the side before it was drawn in At the beginning, the training was limited to these three positions given in a somewhat random order and this stage is referred to as preliminary settings (Table 3, Column 2). From this point onward, the data are included as regular training trials in Column 3, regardless of rake position.

The task at Position A would seem to be very similar to that of pulling in a string, which had been performed in an earlier experiment (6) by these animals. Almost from the beginning, all of the animals were able to do this However, four of the five rhesus monkeys had difficulty when the rake was placed at the *B* and *C*

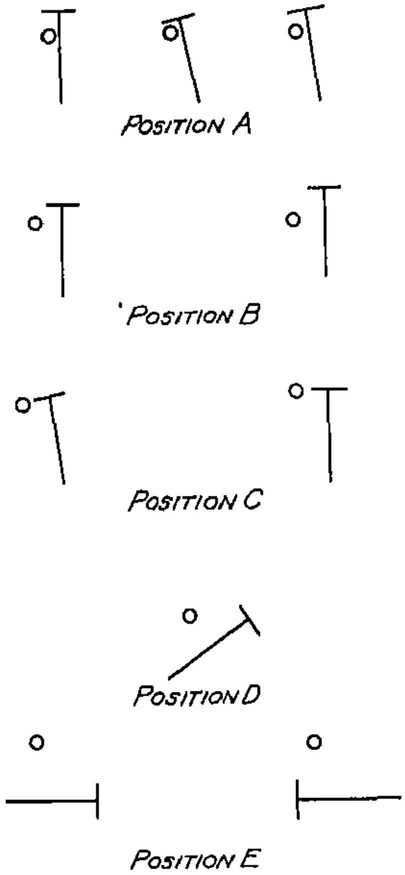

FIGURE 2
Series of Rake Positions

positions. Two of them failed to master these positions and had to be dropped from the experiment (see legend, Table 3). This preliminary stage included a considerable amount of coaching as an aid to solution. This usually involved putting the rake in position with the shutter open, a partial drawing in of the rake by the experimenter, and the like. One rhesus (No 3) and the three cebus monkeys required no preliminary training; they were able from the beginning to manipulate the rake in the manner required

TABLE 3

SUMMARY OF RESULTS IN LEARNING TO USE A SINGLE RAKE TO SECURE FOOD CUP

Animal	Preliminary training Settings	Preliminary training Trials	Average minutes per trial	Settings	Positions of rake *A*	*B*	*C*	*D*	*E*	Successful trials	Failure trials	Perfect trials	Perfect trials in last 20	Types of error *a*	*b*	*c*	*Total*
Cebus 1	0	174	2.9	260	23	67	45	51	74	88	86	26	4	25	31	4	60
Cebus 2	0	110	3.6	200	28	88	23	44	17	48	62	33	14	17	9	66	92
Trader	0	88	3.4	160	2	9	0	109	40	50	38	17	7	1	38	75	114
Rhesus 1	456	158	1.5	193	0	3	74	53	63	110	48	42	4	10	35	23	68
Rhesus 3	0	335	2.3	500	30	182	83	116	89	171	164	104	8	20	31	100	151
Rhesus 4	332	142	1.2	177	0	7	22	33	115	106	36	44	6	2	46	20	68

The error scores refer to the number of trials on which these several types of behavior occurred, rather than to the total frequency of occurrence The records of 2 rhesus monkeys (Nos 2, 5) are not included in the table, since they did not advance beyond the preliminary stage (Column 2) after 475 and 440 settings respectively

The results of the problem, from this preliminary stage onward, are analyzed in Table 3. The number of trials required for each animal to learn to use the rake at Position *E* (Figure 2) are shown in Column 3, and the average time per trial in Column 4. It was found advisable, in order not to discourage the animals too much, to allow several settings per trial, if necessary Thus an animal might fail on one or more settings but still, if finally successful, be rewarded on a given trial. In some cases also, the later settings of a trial were made with the shutter open, so the animal could observe Sometimes failure on a setting meant merely that the animal persisted in pushing or throwing the rake out of reach The number of settings per trial ranged from one to eight, the average being somewhat less than two, as indicated in Column 5 of Table 3. As might be expected, the need for additional settings decreased as the general problem was mastered. The position of the rake (Figure 2) for each setting is given in Column 6 of the table.

All trials were rated as either successes or failures and the record for these is given in Columns 7 and 8 of Table 3 A successful trial was one on which food was secured on the final setting even though errors had been made Failure was recorded when the animal was unable to draw in the food cup after a number of settings or when the shutter was closed to break the animal of the habit of throwing or pushing the stick out of reach. The total number of perfect trials made by each animal is given in Column 9, and the number made during the last 20 trials of the training in column 10. A perfect trial was one on which the animal worked continuously at the task and was able to draw in the food-cup without making errors on a single setting. Although numerous kinds of errors were checked, only the following three types appeared to be significant· (*a*) reaching with hand or foot without using the rake, (*b*) using the wrong end of the rake after turning it about, and (*c*) pushing or throwing the rake out of reach. As can be seen, the frequency of these several types of errors varied considerably from one animal to another. The first type of error was limited very largely to the early trials, as might be expected As the animals attained reasonable facility, they were passed along from one rake position to another, until they had mastered the final position (*E*, Figure 2). The animals were able, at this point, to use the rake as an instrument, when it was placed in front of the bars parallel to the shutter, with the bar in either the left or right position

The results of Table 3 are of interest chiefly as a summary of the amount of training required by each animal in learning to use a single rake It is impossible to make direct comparisons from animal to animal because the frequency of the several rake positions varied greatly. On the whole, it appears that cebus monkeys need much less training than the rhesus monkeys in this early stage of instrumentation. As already noted, two of the three rhesus monkeys that succeeded required a long period of preliminary training, involving coaching, before they could be advanced to Position *B* This is the first position that involves anything beyond a mere drawing in of the rake Moreover, the other rhesus required approximately twice as many trials as any of the cebus monkeys in the mastery of the later and more difficult positions This finding tends to confirm the tentative conclusion, drawn from our patterned strings experiment (6), that manual manipulation is somewhat better developed in the cebus monkeys. In any case, on this initial test they made use of the rake as an instrument more naturally and speedily than the rhesus monkeys It is possible, of course, that interference effects from the earlier patterned strings situation, may have influenced this initial test. This would hardly be an argument against our present conclusion, however, inasmuch as both types of monkeys had learned the string problem at the same time The present test was begun by each animal within a few days after the string problem had been completed.

2 *Multiple-Rake Problem*

This problem may be regarded as a continuation of the one described above, since it involved merely the use of additional rakes in progressively complex series The procedure was in general the same The first stick in each series was placed at Position *E* as indicated in Figure 2 The additional rakes were arranged in order on the ledge device illustrated in Figure 1 Only a single setting per trial was allowed in the present task regardless of the length of the series The criterion for successful and perfect trials was the same as before A trial was recorded as a failure when the animal stopped work for one minute, or when it was necessary to close the shutter in order to break the habit of pushing or throwing the rake out of reach The latter type of behavior seldom occurred and not at all in the case of some animals No reward was secured on the failure trials No hard and fast criterion could be used in determining when to advance an animal from one step to another. In the last analysis, such shifting depended on the judgment of the experimenter as to facility in handling the rakes, and consistency of successful trials with a fair percentage of perfect performances. The mastery of a given step also presumed persistence in attacking the problem.

The types of errors occurring in this complex problem naturally differed from those brought out by the use of a single stick. Although many errors were checked on the data sheets, only the following were of sufficient significance to warrant inclusion in the tables: (*a*) failure to use rake after being drawn in, (*b*) using one or more rakes in the wrong order; (*c*) turning rake about and using the wrong end; (*d*) pushing or throwing one or more rakes out of reach. It should be noted that the record of errors in the tables refers to the number of trials on which the several types of behavior occurred. Repetitions of a given error on the same trial could not be accurately recorded, because of the speedy movements of the animal Numerous types of activity, such as climbing about, pacing the cage, sitting, chewing the rake, number of rakes used, etc., were recorded. Here again, only the trials on which such types of behavior occurred once or more could be checked. Since the data as taken would yield no quantitative measure of the total amount of such activities they have not been reported The length of the rakes used in the several serial steps are given in Table 2

As originally planned, this experiment was designed to determine the limits of capacity in the two species so that definite comparisons could be made. As a matter of fact, we had no reason to expect that either species would be able to advance beyond a fairly short series In previous studies on monkeys only a single instrument (rake, T-stick, cloth) had been employed As the test proceeded, however, it became apparent a definite limit could not be established within a reasonable time. It is true that three of the monkeys (one cebus, two rhesus) reached the limit at the four-rake level, under our training conditions. Nevertheless, the three other animals (two cebus, one rhesus) were able to advance through the eight-rake series and apparently could have gone considerably further. The problem was stopped at this point because the last stick of the final series

TABLE 4

SUMMARY OF RESULTS ON THE MULTIPLE-RAKE PROBLEM FOR CEBUS MONKEYS

Animal	No rakes	No trials	Average minutes per trial	Per cent successful trials	Per cent perfect trials	Perfect trials in last 20	Types of errors			
							a	*b*	*c*	*d*
Cebus 1	II	56	1.4	85.7	14.3	5	7	11	8	23
	III	47	2.0	72.3	25.5	8	1	17	1	19
	IV	25	0.9	96.0	48.0	10	0	3	0	5
Cebus 2	II	37	1.3	78.4	13.5	4	0	3	1	14
	III	17	0.9	100.0	70.6	12	0	1	1	1
	IV	32	1.7	90.6	34.4	7	0	8	0	11
	V	10	1.7	100.0	40.0	4	0	1	0	4
	VII	18	4.0	55.6	11.1	2	0	5	0	4
	VIII	25	1.9	96.0	64.0	13	1	2	1	0
Trader	II	33	1.4	66.7	6.1	2	4	10	10	18
	III	36	1.5	80.6	11.1	4	0	2	7	24
	IV	15	1.4	100.0	20.0	3	1	4	2	5
	V	10	0.9	100.0	70.0	7	0	2	1	1
	VII	10	2.4	100.0	40.0	4	0	1	2	2
	VIII	26	1.7	100.0	50.0	10	7	9	3	4

Note: The six-rake series was omitted in order to extend the series as far as possible within the allotted time

TABLE 5

SUMMARY OF RESULTS ON THE MULTIPLE-RAKE PROBLEM FOR RHESUS MONKEYS

Animal	No rakes	No trials	Average minutes per trial	Per cent successful trials	Per cent perfect trials	Perfect trials in last 20	Types of errors			
							a	*b*	*c*	*d*
Rhesus 1	II	60	1.0	86.7	8.3	5	9	19	36	7
	III	20	0.6	100.0	50.0	10	0	8	3	0
	IV	25	0.7	100.0	32.0	7	0	3	15	1
Rhesus 3	II	78	0.9	78.2	14.1	10	31	44	5	21
	III	30	0.9	83.3	33.3	9	0	2	0	14
	IV	20	0.9	90.0	50.0	10	0	3	0	2
	V	18	1.2	100.0	50.0	9	0	3	0	0
	VII	12	3.1	75.0	8.3	1	0	3	0	6
	VIII	24	4.0	66.7	8.3	2	0	4	1	8
Rhesus 4	II	118	0.8	77.9	3.4	2	16	43	69	28
	III	60	1.0	81.7	30.0	9	1	31	11	5
	IV	25	0.4	100.0	48.0	8	0	8	0	4

Note The six-rake series was omitted in order to extend the series as far as possible within the allotted time was so long that it was very cumbersome to use after the animal had secured it. As a matter of fact, this rake was approximately twice as long as the animal's arm.

As indicated in Tables 4 and 5, the amount of training required on each of the several stages was not very great Much of this training involved little more than practice in facility of using the rakes as they became longer from stage to stage. As the error scores show, the animal seldom failed to grasp the rakes properly or to use them in the proper sequence Naturally, the mechanical difficulties of drawing in the food cup with facility increased greatly as the rakes were lengthened in the later series. Some of the animals, at least, acted as if they knew at once what to do on being advanced from one stage to another This was especially true after the general pattern of using one rake to draw in another had been established. As will be noted, the six-rake series was omitted entirely. This omission did not confuse the animals and did not raise the scores, in terms of trials, for the learning of the seven-rake series. It seems reasonable to conclude, on the basis of these facts, that the more intelligent monkeys were able to generalize the factor of ordinal pattern in passing from the earlier to the later stages of the problem Such generalization need not have involved anything beyond the recognition of similarity in perceptual relations under the conditions of the test

It is impossible to draw any definite conclusions concerning the relative ability of the two species from our data In the first place, the number of animals of each type was too small to offer a basis for species comparison Moreover, the results did not break clearly along species lines For example, one cebus monkey along with two rhesus monkeys did not advance beyond the four-rake series The other two cebus monkeys continued through the eight-rake series, and might have advanced much farther if the tests had been continued Only one of the three rhesus monkeys showed a similar record On the whole, the results seem to lend some support to the conclusion drawn from the single-rake problem discussed above. This conclusion was to the effect that manual manipulation is somewhat better developed in the cebus monkeys In the present test, only one rhesus as compared with two cebus monkeys was able to advance through the entire series employed Moreover, this rhesus monkey required about 25 per cent more trials than either of the cebus monkeys in reaching this point. The number of errors made by this animal was also considerably greater. The opinion that the cebus is somewhat superior to the rhesus monkey in manipulation of this type must be regarded as tentative until much larger groups have been tested.

D. SUMMARY

Two types of monkeys (three cebus, five rhesus) were given the task of securing food by the use of instruments placed on a platform in front of a barred cage. The first problem involved training the monkeys to make use of a single rake or T-stick regardless of its position on the platform Two of the five rhesus monkeys failed on this task after long training. All of the cebus monkeys and the other three rhesus monkeys were successful, although the latter required much more training (including coaching) than the former. The second problem involved the use of multiple rakes in series ranging from two through eight. Only three of the animals (one rhesus, two cebus) were able to advance through the entire series, and these could have gone farther, probably, had the experiment been continued. The results are interpreted as favoring the tentative conclusion that this type of manual manipulation is considerably better developed in cebus than in rhesus monkeys

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IMITATIVE BEHAVIOR IN CEBUS AND RHESUS MONKEYS*[1]

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A. Introduction

As shown by the recent summary of Warden and Jackson (8), the early work on imitation in birds and mammals yielded, in the main, negative results. Thorndike found no evidence for imitation in chicks, and the results of Porter on various species of birds are inconclusive. Small decides against imitation in the white rat, whereas Berry argues for a low order of imitation in this type. The negative results of Thorndike on the cat and dog are well known. Berry and Hobhouse insist that cats possess a low order of imitativeness The tests of Cole and Davis on the raccoon were disappointing. In general, the opinion has steadily gained ground that genuine imitation does not occur among the subprimate forms.

The results to date on monkeys and apes are more or less inconsistent and confusing Thorndike found little or no evidence for intelligent imitation in monkeys, and the instances cited by Hobhouse are not very convincing. Shepherd concludes that imitation, when present at all, is of little importance in the learning of monkeys The results of Watson were negative, regardless of whether the imitatee were another monkey or himself Kinnaman (3) reports two cases of imitation in the rhesus monkey, but these followed a considerable amount of practice on the task Haggerty (2) offers the best evidence from these earlier studies for imitation in monkeys Instances of clear-cut imitation were limited to a few of the animals tested, and some of the tasks involved were exceedingly simple for primates He reports numerous cases of "partial" imitation in which observation apparently aided the imitator somewhat in solving the problem by trial-and-error activities. As a rule, however, the monkeys were allowed practice at the task before being tested for imitation.

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[1] This report covers one topic in a project on Intelligence in Monkeys (under the direction of Professor C J Warden), supported by the Council for Research in the Social Sciences of Columbia University

[2] The general method employed was devised by the senior author who is also responsible for the present report The junior authors carried out the tests and made the statistical computations of the tabular materials

Several workers have noted instances of social facilitation and simple imitative behavior in the great apes. Nevertheless, both Yerkes (12) and Kohler (6) seem to feel there is little reason to suspect a high order of imitativeness even in the chimpanzee.

Most of the studies cited above made use of the *Observation-Cage* method which was devised by Thorndike. After the imitatee had been trained, the imitator is allowed to observe him at work from a cage attached to the working cage. When sufficient time has been allowed for observation, the imitatee is removed from the working cage and the imitator transferred thereto. As pointed out by Warden (8, 9) the following criticisms apply to this method: (*a*) A shifting about of the animals may involve a considerable delay between observation and the imitative act; (*b*) the shifting may induce an emotional disturbance in the imitator; (*c*) the shift may disrupt the mental set to imitate. It seems altogether likely, indeed, that the negative results reported on primates by the earlier workers were due in large part to such arbitrary factors which are inherent in the method itself.

In 1930, the *Duplicate-Cage* method was devised by Warden (9) and was later used by Warden and Jackson (8) in testing the imitative behavior of 15 rhesus monkeys. This method involves the presentation of a duplicate puzzle device to the imitator in the observation cage. This makes it unnecessary to shift either of the animals about during a given work period. The imitator may react at once, upon observing the imitatee, since the puzzle device is ready at hand. Moreover, the imitative tendency when aroused is not disrupted by a shift of any sort. As previously observed, this method provides the natural setting for the occurrence of imitative behavior in animals and children. When tested by this method, the rhesus monkey (8) exhibited a marked capacity to learn various problem devices by means of imitation. The present study may be regarded as a continuation of this work to cebus as well as other rhesus monkeys.

B. Method and Procedure

The six monkeys used in this investigation may be classified as follows two common cebus (*Cebus capucina*), one weeper capuchin (*Cebus apella*), and three rhesus (*Macaca mulatta*) The weeper capuchin (Trader) was supplied by Dr C R. Carpenter The other cebus and the rhesus monkeys were secured from local dealers and were three to three and one-half years old when tested The three cebus monkeys and Rhesus No 2 were males, and Rhesus No 3 and No. 4 were females. The animals were well adjusted to laboratory work before the imitation tests were begun. All of the monkeys had previously been used in the study on patterned strings (10), and in the study on instrumentation (11) as well. The care of the animals followed the usual Columbia Laboratory routine, as described in detail by Fjeld (1) and Koch (5) Each monkey was caged alone while in the laboratory to prevent the formation of distracting social attachments. Raisins were used as the reward, since they were known to possess a high incentive value for both types of monkeys

A diagram of the apparatus employed is shown in Figure 1. Each of the two compartments measured 36 inches long, 30 inches wide, and 36 inches high. The dividing screen was made of ½-inch

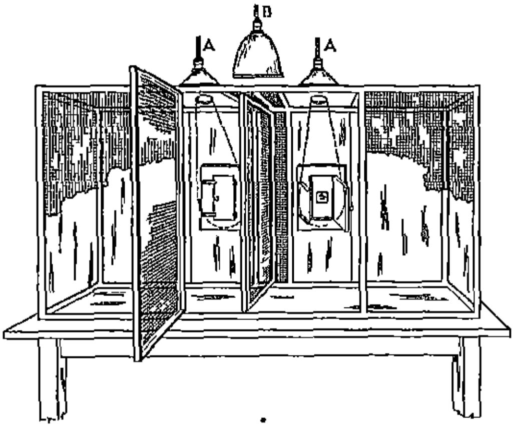

FIGURE 1

Warden Duplicate-Cage Imitation Apparatus

The cages for imitator and imitatee, separated by a wire mesh partition, are similar in every respect The lights, *A*, *A* flood the puzzle devices during the test to enhance observational stimulation The setting is for Problem IV except that the device on the right side is open so the position of the incentive can be seen wire mesh which permitted clear observation of the movements of the imitatee Preliminary tests have shown that the monkey may be distracted by the presence of the experimenter in the room, hence a one-way light screen was employed This involved covering the top of the cage with heavy black cloth and the back and sides with beaver board. A screen of rayon cloth through which the experimenter could observe the animals was lowered in front of the cage before making each test. The inside of each compartment was illuminated by an automobile spotlight (32 candle power) focused directly upon the panel bearing the puzzle device In addition to supplying general illumination, these lights tended to enhance the stimulation value of the puzzle devices. The large central light was not used during the testing period and all lights in the room were turned off before beginning a test. A large electric fan was operated at low speed to serve as a sound screen.

The puzzle devices were mounted on removable panels as indicated in Figure 1. The panels were placed close to the division screen so as to favor ready observation In this position the imitator was enabled to secure a profile view of the imitatee during his attack upon the problem The following tasks, arranged in order of difficulty, were employed· (*a*) Pulling a chain which hung down within easy reach in front of the panel, thus raising a door and exposing a raisin in a hole in the panel; (*b*) opening a door in the panel, behind which a raisin had been placed, by manipulating a knob; (*c*) operating a simple latch and then opening the door; and (*d*) operating two latches (upper, lower) arranged as in Figure 1, and then opening the door. As will be seen, the last three problems represented a progressive series of acts. The four problems were first learned by the imitatee and then presented to the several imitators in the order given above These problems were precisely the same as those in the earlier study (8) It was there shown by testing a control group that each of the problems is above the instinctive level, hence genuine learning is required to solve them. No further control group was necessary, therefore, in the present study. The time required to train the imitatee by trial and error, aided by coaching, was many times as great as that allowed in the series of imitation tests.

The general procedure was the same as that used in the earlier study The imitator was allowed to adjust to the testing conditions by being placed in the cage for 10 minutes daily on from one to four days as required During this period practice was prevented by the use of blank panels in the cage The imitatee was in the opposite side and the lights, light-screen, and the guide-cords (to control the animal) were manipulated as in the experiment proper. A female monkey (Rhesus No. 1), after being trained as the imitatee, had to be discarded at this stage because Cebus No. 1 was very much afraid of her A male animal (Rhesus No. 5) was trained and used thereafter as the imitatee. So far as could be observed this animal occasioned no emotional upset in any of the imitators tested

In the experiment proper an animal was given six tests on each problem before being advanced to the next. As a rule the six tests were made on the same day, although the series was broken by a 24-hour interval in some cases An interval of four days intervened between one problem and another, in order to reduce any possible transfer and interference effects. As will be seen, each animal was given 24 tests of imitation altogether, thus making the group total 144

The test procedure was precisely the same as that used in the earlier study and may be indicated very briefly The two animals, with cords attached, were placed in their respective compartments, and anchored in the proper position by the experimenter The two puzzle devices were set and baited by an assistant[3] stationed behind the apparatus The room lights were then turned off. The panel of the imitatee was then illuminated by means of the spot light and the imitatee allowed to perform. The animal was drawn back to the corner of the cage, the light turned off, and the puzzle device re-set. This procedure was repeated five times in rapid succession, the five performances of the imitatee requiring only about 30 seconds Immediately after the fifth performance, the light was turned off in the imitatee's compartment and flashed on in the other compartment. The imitator was released and allowed 60 seconds in which to solve the problem just observed The imitator was usually leaning forward against the taut cord and often went directly to the panel. If the problem had not been solved within the 60-second period, the imitator was drawn back to the corner of his compartment. The exact time required for each solution was taken with a stop-watch.

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[3] Thanks are due to Dr G M. Gilbert for valuable aid in this connection

C. Results

The results have been analyzed into the following degrees of imitativeness, as was done in the earlier study:

I, immediate imitation—solution of task within the 60-second test period

P+, partial imitation—proper act occurred but not exact or forceful enough to work the mechanism

P, partial imitation—contact made with proper part of mechanism but appropriate movement incomplete

P—, partial imitation—puzzle device approached and parts inspected but without body contact with it

F, failure to imitate—no apparent attention to puzzle device

The individual records for the six tests on each of the four problems are presented in Table 1. The records for a given performance include the time score and a rating as to the degree of imitativeness exhibited. The ratings are assigned in accordance with the letter system indicated above The time scores vary considerably when imitation (immediate or partial) occurs, depending on the moment when the appropriate act took place. Obviously, the shorter the time the less the opportunity for trial and error activity to enter into the solution

As indicated in Table 1, no outright failures occurred in the present study This means that some degree of social facilitation was shown on each of the 144 tests There were 110 cases of immediate imitation and 34 cases of partial imitation (*P+*, *P*, *P—*). The amount of imitative behavior exhibited showed little variation from task to task The number of instances of immediate imitation on the series of tasks was as follows: 25, 33, 26, 26 The corresponding scores for partial imitation were 11, 3, 10, 10 A summary of the several types of imitative behavior for each problem is given in Table 2 As will be seen, 10 of the 34 cases of partial imitation fall into the *P+* category. This means that the proper pattern of response was copied by the imitator, but not with enough exactitude or force to operate the essential mechanism. The other two types of social facilitation (*P—*, *P*) involved little more than an enhancement of the stimulus in the setting. It is apparent, from this analysis, that the pattern of response was actually copied in 120 out of 144 tests.

The data bearing on the relative imitative ability of the different

TABLE 1

SHOWING THE RECORD OF EACH MONKEY ON THE FOUR PROBLEMS
(SIX TESTS ON EACH)

Animal and problem	Test 1		Test 2		Test 3		Test 4		Test 5		Test 6	
	Sec	*R.*	Sec.	*R*	Sec	*R.*	Sec.	*R*	Sec	*R*	Sec	*R*
Problem I												
Cebus 1	25	*I*	20	*I*	18	*I*	12	*I*	14	*I*	4	*I*
Cebus 2	60	*P*	60	*P*	32	*I*	60	*P*+	60	*P*+	46	*I*
Trader	60	*P*	60	*P*+	22	*I*	60	*P*+	8	*I*	60	*P*+
Rhesus 2	60	*P*	25	*I*	5	*I*	5	*I*	3	*I*	4	*I*
Rhesus 3	7	*I*	10	*I*	9	*I*	8	*I*	4	*I*	3	*I*
Rhesus 4	60	*P*+	60	*P*+	25	*I*	17	*I*	6	*I*	5	*I*
Problem II												
Cebus 1	60	*P*	60	*P*+	57	*I*	2	*I*	2	*I*	2	*I*
Cebus 2	39	*I*	14	*I*	10	*I*	4	*I*	12	*I*	4	*I*
Trader	2	*I*	2	*I*	2	*I*	2	*I*	1	*I*	5	*I*
Rhesus 2	31	*I*	20	*I*	4	*I*	2	*I*	2	*I*	2	*I*
Rhesus 3	11	*I*	3	*I*	9	*I*	14	*I*	3	*I*	7	*I*
Rhesus 4	21	*I*	60	*P*	19	*I*	4	*I*	3	*I*	1	*I*
Problem III												
Cebus 1	11	*I*	8	*I*	3	*I*	16	*I*	25	*I*	49	*I*
Cebus 2	2	*I*	14	*I*	1	*I*	13	*I*	3	*I*	1	*I*
Trader	60	*I*	25	*I*	60	*P*+	40	*I*	5	*I*	40	*I*
Rhesus 2	60	*P*	60	*P*	60	*P*	60	*P*	60	*P*	60	*P*
Rhesus 3	13	*I*	27	*I*	60	*P*	60	*P*	15	*I*	45	*I*
Rhesus 4	60	*P*+	5	*I*	25	*I*	10	*I*	5	*I*	25	*I*
Problem IV												
Cebus 1	4	*I*	48	*I*	60	*P*	59	*I*	60	*P*	60	*P*
Cebus 2	23	*I*	13	*I*	12	*I*	8	*I*	7	*I*	8	*I*
Trader	9	*I*	9	*I*	9	*I*	19	*I*	13	*I*	10	*I*
Rhesus 2	60	*P*	60	*P*	60	*P*—	60	*P*—	60	*P*—	60	*P*—
Rhesus 3	31	*I*	60	*P*	18	*I*	33	*I*	48	*I*	25	*I*
Rhesus 4	19	*I*	49	*I*	19	*I*	18	*I*	30	*I*	7	*I*

For the meaning of the letter rating under *R*, see analysis of types of imitative behavior in text above

TABLE 2

GROUP AVERAGES AND PERCENTAGES ON ALL PROBLEMS

Degree of imitation	Total animals	Prob I cases		Prob II cases		Prob III cases		Prob IV cases		Total cases	
		No	%	No	%	No	%	No	%	No	%
I	6	25	69.4	33	91.7	26	72.2	26	72.2	110	76.4
P+	6	7	19.4	1	2.8	2	5.5	0	0.0	10	6.9
P	6	4	11.2	2	5.5	8	22.3	6	16.6	20	13.9
P—	6	0		0		0		4	11.2	4	2.8
F	6	0		0		0		0		0	

TABLE 3

SHOWING THE RECORD (*Immediate Imitation*) OF EACH ANIMAL ON THE FOUR PROBLEMS IN TERMS OF AVERAGE SCORE

Animal	Prob. I		Prob II		Prob III		Prob. IV		Totals	
	No cases	Av. sec	No cases	Av sec	No cases	Av sec.	No. cases	Av sec	No cases	% suc.
Cebus 1	6	15.5	4	15.8	6	18.7	3	37.0	19	79.2
Cebus 2	2	39.0	6	13.8	6	5.7	6	11.8	20	83.3
Trader	2	5.0	6	2.3	5	34.0	6	11.5	19	79.2
Rhesus 2	5	8.4	6	10.2	0	0.0	0	0.0	11	45.8
Rhesus 3	6	6.8	6	7.8	4	25.0	5	31.0	21	87.5
Rhesus 4	4	13.3	5	9.6	5	14.0	6	23.7	20	83.3

animals, in terms of the immediate imitation scores, are given in Table 3. The differences are not marked, except in the case of Rhesus No. 2, who succeeded on somewhat less than half the tests. The other five animals ranged from 19 to 21 successes out of the 24 tests given to each animal. The question of generic differences can hardly arise in view of the small number of each type tested. Nevertheless, it may be noted, except for Rhesus No. 2, the cebus and rhesus monkeys made about the same showing.

As already noted, all instances of immediate imitation involved successful performance within the 60-second test period. In many instances, however, the imitative act occurred within a few seconds after observation of the imitatee. The temporal distribution of the 110 cases of immediate imitation is shown in Table 4. In 57 cases (51.8%), imitation occurred within 10 seconds, and in 38 cases (34.5%) within five seconds. Such speedy performance would eliminate the possibility of trial and error activities of any consequence. Moreover, a check of the detailed records indicates that in at least 40 of the 57 cases mentioned above, no such activities occurred. In these instances, the pattern of movement of the imitatee was followed precisely and without excess or fumbling movements. As a matter of fact, 94 of the 110 cases of immediate imitation fell within the first half of the 60-second test period. In numerous instances the time score was lengthened because of the fact that the animal hesitated somewhat before approaching the panel. A high time score, therefore, does not necessarily mean a large number of excess or trial and error movements.

As has been noted, each animal was given six tests on a given problem before being passed on to the next. This schedule raises

TABLE 4

SHOWING THE TEMPORAL DISTRIBUTION OF IMMEDIATE IMITATION SCORES WITHIN THE TEST PERIOD (60 SECONDS)

Time interval (seconds)	Frequencies				
	Problem I	Problem II	Problem III	Problem IV	All problems
0- 1	0	2	2	0	4
1- 2	1	10	1	0	12
2- 3	2	3	2	0	7
3- 4	3	4	0	1	8
4- 5	3	1	3	0	7
5- 6	1	0	0	0	1
6- 7	1	1	0	2	4
7- 8	2	0	1	2	5
8- 9	1	1	0	3	5
9-10	1	1	1	1	4
11-15	2	4	5	3	14
16-20	3	2	1	5	11
21-25	3	1	4	2	10
26-30	0	0	1	1	2
31-35	1	1	0	2	4
36-40	0	1	2	0	3
41-45	0	0	1	0	1
46-50	1	0	1	3	5
51-55	0	0	0	0	0
56-60	0	1	1	1	3
Median time	7.3	3.8	13.0	19.0	9.5

TABLE 5

SHOWING THE PRACTICE EFFECT (THROUGH SIX TESTS) ON IMMEDIATE IMITATION

Problem	Test 1		Test 2		Test 3		Test 4		Test 5		Test 6		Total	
	I	Sec	*I*	Sec	*I*	Sec.	*I*	Sec	*I*	Sec	*I*	Sec	*I*	Sec
I	2	16.0	3	18.3	6	15.2	4	10.5	5	7.0	5	12.4	25	12.7
II	5	20.8	4	9.8	6	16.8	6	4.7	6	3.8	6	3.5	33	9.6
III	4	21.5	5	15.8	3	9.7	4	19.8	5	10.6	5	32.0	26	18.7
IV	5	17.2	4	29.8	4	14.5	5	27.4	4	24.5	4	12.5	26	21.1
Total	16		16		19		19		20		20		110	

I refers to the number of cases of immediate imitation for all animals; *Sec.* to the average time in seconds for imitation

the question of practice effects within each series of tests, and throughout the experiment as a whole. An analysis of the data on this point will be found in Table 5. The number of cases of immediate imitation, together with the average time of performance, is given for each of the six tests These data are indicated separately for the several problems. It is obvious that practice effects might be manifested either in a greater number of successes or in speedier reactions as the tests continued. There was no practice effect from Test 1 to Test 2, when the data for the four problems are pooled, as indicated in the last array of Table 5 There is a rise, however, from Tests 3 to 6, in the number of cases of immediate imitation as well as in average speed of response Such practice effects may have reflected either better observation or a smoother manipulation of the puzzle devices. It is impossible to interpret the results, relative to the effects of practice through the several problems, since the tasks were made more complex as the work advanced.

On the whole, the present results demonstrate about the same level of imitative capacity in monkeys as those of the earlier study by Warden and Jackson (8). This is hardly surprising since the *Duplicate-Cage* method was used in both investigations, and the procedure, schedule of testing, and method of scoring were the same. Moreover, in both cases the monkeys had been previously trained on some other laboratory apparatus, and hence were probably about equally well adjusted to handling and test conditions. The present results should be compared only with those of the "satisfactory" group of the former study This group was formed by eliminating six females that were so distracted by the male imitatee that they observed very little and failed on most of the tests. The "satisfactory" group there reported showed 72.4 per cent immediate imitation score and 22.9 per cent partial imitation score. The corresponding values in the present study were 76.4 per cent and 23 6 per cent In the earlier study the group showed only 4 8 per cent failure scores, whereas no failures occurred in the present study. The slight differences in the results of the two experiments clearly fall within the range of individual differences.

It seems obvious that the old notion that monkeys do not imitate must be abandoned, in view of the results of these studies, involving two generic types (rhesus, cebus) and three species. It should be emphasized, in this connection, that more rigid controls were applied in these studies than had been used by any of the earlier workers In fact, the generally accepted criteria of imitation (8, 9) were carefully fulfilled for the first time. The tasks employed were sufficiently novel and complex to involve a genuine learning process;

the responses classed as immediate imitation appeared promptly after observation of the imitatee, previous practice was excluded by the experimental conditions; the responses of the imitator was substantially that of the imitatee, and a large enough number of instances occurred on the various problems to eliminate the chance factor Up to the present, no one has suggested a more rigid set of criteria. In view of these findings, it seems altogether likely that the negative results of previous investigators were due in large measure to the arbitrary method (*Observation-Cage*) employed This suggests the need of retesting such sub-primate mammals as the dog and cat, by the *Duplicate-Cage* method, before drawing conclusions as to the imitative capacity of these types.

D SUMMARY

1. Six monkeys (three rhesus, two common cebus, one weeping capuchin) were tested for imitation by means of a newly devised procedure (Warden *Duplicate-Cage* method) on four manipulative problems, six tests being given on each task.

2 Immediate imitation (success within 60 seconds) occurred in 76.4 per cent of the 144 tests This compares with a score of 72.4 per cent obtained on nine rhesus monkeys in a previous study in which the same method was used

3. Instantaneous imitation (within 10 seconds) occurred in 57 tests, or approximately one-half of the successes (immediate imitation) In 40 of these 57 cases, the response was made directly without fumbling or trial and error movements.

4. These results demonstrate a high level of imitative capacity in the cebus as well as the rhesus monkey.

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CASE STUDIES OF IDENTICAL TWINS*

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In the controversy over the relative effects of heredity and environment upon the development of the individual much stress has been laid upon the importance of using so-called *identical* twins as a means of determining the differential modifying effects of environment upon two individuals who have, according to Mendelian rule, inherited the same set of potential characteristic determiners Carter (7), in reporting a case study of a pair of mature *identical* twins, reiterates the desirability of gathering data on isolated sets of twins as they come within reach. Eventually there may be enough cases to warrant their being brought together and reckoned with on a statistical basis as a means of establishing trends which may only then be apparent. Carter offers the opinion that mature *identical* twins, showing few if any differences (on a basis of various standard tests) despite a definite environmental difference created by years of living apart, should be studied in preference to others who have lived together. Because of the nature of the problem to be solved and the necessity for utilizing certain well-known statistical procedures in arriving at even a theoretical answer, it would appear to be equally important as an *experimental control* to gather information on the latter type also Hence data have been procured and are presented on three sets of *identical* twins of college age who, in each case, have been reared together.

A. DIAGNOSIS

Much has been said regarding the diagnosis of twins as *fraternal* or *identical* The main criticism has been directed toward the impossibility of ever establishing beyond doubt the fact of uniovularity in any particular instance despite evidence at birth of monochorionic enclosure Reasons for such criticism have been the occurrence on scattered occasions of chorionic fusion as in the cases reported by

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Arey (3) and Newman (19). Such occurrences are so rare almost as to preclude errors of diagnosis on a basis of the presence of a single chorion. At any rate the future use of a large number of cases would minimize the effects of such exceptions Critics would say that, should it be possible to observe the actual process of embryonic division into two individuals, then only would it be safe to assume their identity of hereditary determiners. Is it any more of a scientific error to assume their derivation from a single fertilized ovum on a basis of monochorionity than it is for the critics of this assumption to accept the postulates of Mendelian genic determiners? In order to make any progress at all, both assumptions are necessary, the former undoubtedly coming closer to fact than the latter, and hence being more liable to acceptance as fact. There is usually no argument over the secondary criteria of diagnosis, if the above primary situation can be demonstrated to exist.

Since, in the three cases studied here, such natal evidence of monochorionity was available, the author has, with additional evidence to be presented below, diagnosed these three sets of twins as *identical, or in biological terms, as monozygotic, uniovular, or* homologous.

Newman (17), probably the most eminent worker in the field of twins and the twinning process, has set up certain secondary diagnostic criteria which include various well-known types of physical resemblances, *the most important of which he considers to be strong* resemblance in the "microscopic character of the papillary ridges in fingers and palms" (17, p. 290) He states that "there must be stronger cross resemblance than internal resemblance in one or more of the details of finger and palm patterns" Moreover, Newman considers similarity of palm and skin patterns to be "the best single diagnostic aid, not so much between the two hands of one person, as between the corresponding hands of the two members *of a twin pair." In this connection he says*

> Specifically the right hand of one twin is more like the right hand of the other than like his own left hand, and the left hand of one twin is more like the left hand of the other than like his own right hand. Thus, cross resemblance between the two individuals is stronger than resemblance between the two hands of the same individual. . *In every pair of obviously monozygotic twins, the rule holds, that there is a*

> *stronger cross resemblance between the hands of one twin and those of the other, than between the two hands of the same individual* (17, p 291)

Newman's criteria supplemented by the techniques of Siemens (20) and Bonnevie (6) were used here as guides in arriving at a diagnosis of monozygosity

B Case No 1

Twins *D G.* and *L G* are both female and were 20 years of age at the time of the study As stated above they were diagnosed as monozygotic on a basis of monochorionic evidence and by means of the techniques and methods outlined by Newman (17), Siemens (20), and Bonnevie (6) Such a diagnosis is scarcely to be questioned in view of the extreme similarity between these two They are so much alike in physical appearance that this writer, after three months work with them, was still unable to tell them apart In fact there are very few people known to the twins who have been able to uncover a distinguishing difference

1. *Physical Similarities*

Since it is possible that similarities in personality, interests, attitudes, etc , may be dependent to a certain extent upon degree of physical similarity, detailed anthropometric measures and simple physical tests were made and are recorded in Table 1

The test of involuntary movement was made with the familiar steel block containing various sized holes, the score recorded in Table 1 being the smallest hole into which the stylus could be thrust and withdrawn without touching the sides The holes were numbered 1, 2, 3, 4, etc , in order of decreasing diameter The test of voluntary movement utilized a wedge-shaped slot in which a stylus was moved toward the narrow end until it touched the steel sides and thus closed a circuit which rang a buzzer. The score recorded represents the average in cm of three trials.

2 *Finger and Palm Prints*

Finger and palm prints of the twins were examined and found to be strikingly similar in pattern and design when cross-compared By means of Bonnevie's technique, the finger prints were evaluated.

TABLE 2

FINGER PRINT RAW RIDGE COUNT CLASSIFIED ACCORDING TO BONNEVIE'S METHOD (6)

	D G		*L G*	
	Right	Left	Right	Left
Thumb	3.5	3.5	3.5	3.5
Forefinger	2.5	2.0	3.0	3.5
Middle finger	3.5	3.0	4.5	2.5
Ring finger	3.5	3.5	4.0	3.5
Little finger	3.0	4.0	3.0	2.5
Total, each hand	16.0	16.0	18.0	14.5
Total, both hands	32.0		32.5	

TABLE 1

PHYSICAL RESEMBLANCE OF THE TWINS

	D.G	*L.G.*
Weight	162 lbs	167 lbs.
Height	67⅛"	67⅞"
Sitting height	32½"	33⅛"
Reach	71½"	71"
Chest	39"	40"
Waist	30½"	31¼"
Neck	13⅛"	13½"
Hips	40½"	42"
Head circumference	22¼"	22⅝"
Head length	19.20 cm	19.22 cm.
Head width	15.00 cm.	15.05 cm
Cephalic index	78.12	78.30
Eye color	Hazel	Hazel
Hair color	Brown	Brown
Bicep	R. 11¼"	11⅜"
	L 11⅛"	11¼"
Wrist	R. 6⅝"	6⅝"
	L 6⅝"	6¾"
Ankle	R 9⅛"	9½"
	L 9⅛"	9⅝"
Calf	R 15"	15"
	L 15"	15"
Thigh	R 24¼"	24¼"
	L 24"	24¼"
Grip (average of 3 trials)	R. 34.25	34.08
	L 34.92	36.08
Tapping test (average of 3 trials of 30 seconds each)	R 176	183
	L. 162	145
Test of involuntary movement	R. 4	3
	L. 3	2
Test of voluntary movement (average of 3 trials)	R 13 cm	10 cm.
	L 12 cm	12 cm

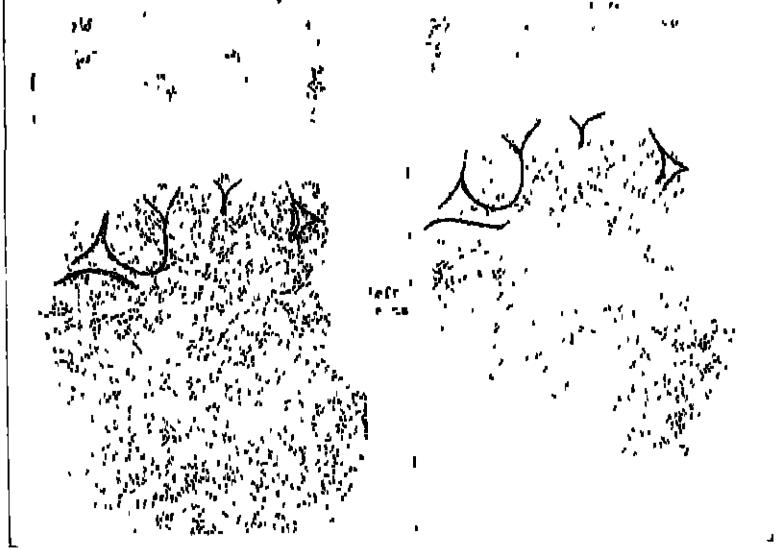
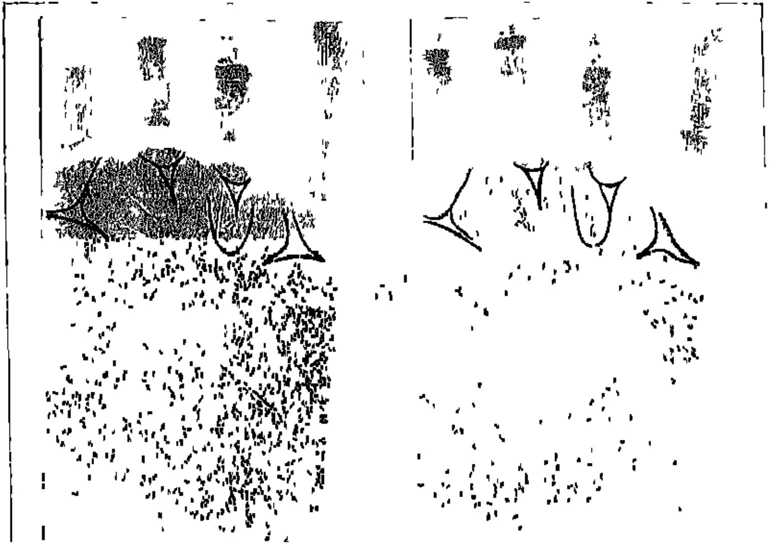


FIGURE 1



The results are presented in Table 2. The palm prints were not quantified but are included here to show the amazing similarity when cross-compared (Figure 1) Certain of the ridges have been darkened so that the similarities are more apparent.

With reference to finger prints, Bonnevie's Table 22 showed the average difference in quantitative indices for her 15 pairs of identical twins to be 6 02, and the range to be from 0.5 to 18.9 For her 16 pairs of fraternal twins, the average difference proved to be 16.09 and the range from 6.0 to 34.0.

The difference in total quantitative values as shown in Table 2 is only 0 5, which is equal to the lower limit of the range for identical twins as determined from Bonnevie's data, a rare and unusually small difference

3 *Asymmetry*

There has been no intensive study made of asymmetry, but an incidental contribution can be made by some of the available data Both twins are righthanded (a fact noticeable in the tapping test, results of which are recorded in Table 1) and neither reports a tendency in early life to be left-handed or ambidextrous. The indication, generally, speaking, is one of the same-sided symmetry for both *D.G* and *L G.*

4 *Developmental Data*

D.G was born 15 minutes before *L.G.* and weighed 6½ pounds, while *L G.* weighed 7½ pounds. *L.G.* has always weighed slightly more than *D G* and has always been slightly taller. Both entered the second grade instead of the first when they began school at the age of five. Various childhood diseases which afflicted both at the same time include whooping cough, which they had at five years of age, mumps at eight years, measles at nine years *D G* also had scarlet fever shortly after she recovered from the measles, and she had a slight attack of measles again when 18 years of age Both wear glasses, each requiring the same lenses as the other. Their total development has been for the most part normal

5. *Environment*

Their father and mother are both 50 years of age and in good health. The father is a graduate of an engineering college and the mother is a graduate of a liberal arts college. The twins have a sister who is 26 years old, and a brother 20, both of whom live at home The sister graduated from a liberal arts college and the brother is a sophomore at a technical school. The parents do not and have not engaged in an active social life and their chief form of recreation is reading. The family's home life is very happy and the parents have never had need to resort to severe discipline

D G. and *L.G.* have always been together There has never been any period in their lives when they have been separated from each other. It is probably true that seldom do two people live more completely in the same environment than do these two They are inseparable on the campus, they room together, always walk together and in step, and are almost tearful if a professor tries to separate them in a classroom *D G* has a job washing dishes in the dormitory and *L G* always helps her Likewise *L G* has a job on the dormitory switchboard, working at different hours from *D,* and while she is at work *D G.* always sits nearby to talk with her. Neither has had any special training not shared by the other. Their interests are the same Both abhor the thought of the teaching profession and want to obtain employment as private secretaries upon completion of their college course They always take the same courses and almost invariably maintain averages within a point of each other. They were both elected to Phi Beta Kappa. The girls have very few close friends and make no attempt to mix in college social affairs. They are more or less completely sufficient unto themselves They do not seek the company of others and apparently prefer to be by themselves Recently *D G* informed the writer that she had attended a movie only three times in her life without having her sister along.

The one point to be emphasized here specifically is that these two girls have always had the "same" or very similar experiences, have never been separated for any period of time, have the same interests and desires, and really come as close thereby to having "identical" environments as it is humanly possible

6 *Personality Traits*

By means of observation and the help of friends of the twins it has been possible to bring forth a few outstanding personality traits. They are both diligent and very industrious This was quite noticeable in their extremely careful attempt to cooperate fully in this study They both show traits of stability, integrity, and consistency which mark them off as persons of high moral character. They are always careful, conscientious, and intelligent in carrying out any task assigned to them The twins are responsive, both have a fine sense of humor, and they are neat and careful in their dress. *D G.* seems to be more dominant for "she always comes first" They both told the writer that *D G.* is always first to sit in the dentist's chair, the first to enter a door, and first in anything that must be done one-at-a-time Having discovered this the writer attempted by subtle methods to induce *L G* to take certain tests such as the tapping test first, but she resisted such attempts and would not do so even when the most persuasive methods were employed; she always insisted upon being second This peculiarity might be interpreted as being due to the fact that *D.G.* is the more submissive of the two, and that *L.G.*, realizing it, forces *D G.* to be ahead of her in all such situations The writer, basing judgment on more objective data discussed below, believes this to be the case.

7. *Interests*

There are no significant differences in interest Neither has any outstanding interest in young men, probably because of a lack of interest on the part of young men in them They are, however, both seen together occasionally in the company of the same male student They both go out with this young man, but always together They both looked upon this study as something very exciting and devoted much time to it, probably because they are seldom the object of attention on the part of men and apparently enjoyed the contact. They enter into most sports open to feminine competition, and into publication work, but neither excels in any special line of extracurricular activity. They both enjoy swimming, the movies, and their chief hobby is collecting newspaper clippings of current events. *D G.* also likes especially to cook and sew.

8 *Measures of Intelligence and Mechanical Aptitude*

On the Otis *Test of Mental Ability* given to prospective college students *D.G.* obtained an *IQ* of 116 and *L G.* one of 120. This writer gave them the Kuhlmann-Anderson *Test.* Raw scores on the individual parts of this test are listed in Table 3 in order to show the similar performance of the twins.

TABLE 3

COMPARISON OF THE RAW SCORES ON THE KUHLMANN-ANDERSON TEST

Test No	*D G*	*L G*
24	7	7
25	10	10
26	15	15
27	28	27
28	12	11
29	12	12
30	15	15
31	14	15
32	14	13
33	15	15
34	15	18
35	17	15
36	10	10
37	20	20
38	10	8
39	9	9

The MacQuarrie paper test of mechanical ability was given and the results are recorded in Table 4 The total scores of *D.G.* and *L G.* vary by three points, but both fall into the same group, low average, as determined by the author of the test. Percentiles were figured by drawing percentile curves from MacQuarrie's data (14).

TABLE 4

MEASURES OF INTELLIGENCE AND MECHANICAL ABILITY

Test	*D G.*	*L.G.*
Kuhlmann-Anderson—Median *MA*	19 yrs 10½mo	20 yrs. 4 mo
IQ	124 22	127 08
MacQuarrie Test for Mechanical Ability		
Tracing	34	37
Tapping	33	38
Dotting	21	21
Copying	24	31
Location	36	40
Blocks	19	14
Pursuit	23	18
Total	190	199
Giving a score of	63	66
Percentile	38	44
Group represented by score	Low average	Low average

TABLE 5

RESULTS OF PERSONALITY TESTS

Test	*D G*	*L G*
Moss, Hunt, Omwake—*Social Intelligence Test*		
1 Judgment in social situations	27	28
2 Recognition of the mental state of the speaker	30	36
3 Observation of human behavior	46	44
4 Memory for names and faces	24	19
5. Sense of humor	19	20
Total score	146	145
Percentile	90	90
Allport and Allport *A-S Reaction Study Score*	—5	—6
Decile	9	9
Interpretation	Third degree of submission	Third degree of submission
Laird *Personal Inventory C-2 Score*	20	15
Interpretation	More introverted than 65% of women	More introverted than 21% of women
Bernreuter *Personality Inventory*		
Percentiles		
B1-N (Neurotic Tendency, low score means well balanced)	4.4	15.0
B2-S (Self-sufficiency, high score means self-sufficiency)	98.0	92.8
B3-I (Introversion-extroversion, high score means introverted)	4.6	11.2
B4-D (Dominance-submission, high score means dominant)	86.0	58.8
F1-C (Self-confidence, low score means great self-confidence)	2.0	9.6
F2-S (Sociability, high score means non-social)	91.8	89.6
Humm-Wadsworth *Temperamental Scale*		
Normal	+1*	+2*
Hysteroid	—3	—2
Cycloid manic	—3	—2
Cycloid depressed	—1	—2
Schizoid autistic	+1*	+1*
Schizoid paranoid	—2	—3
Epileptoid	—1	—2
Bell *Adjustment Inventory*		
Home adjustment	good	good
Health adjustment	good	good
Social adjustment	average	average
Emotional adjustment	excellent	excellent
Total adjustment	good	average

TABLE 5 (*continued*)

Test	*D G*	*L G*
Allport-Vernon *Study of Values* (percentiles)		
Theoretical	5	10
Economical	90	70
Aesthetic	90	80
Social	40	70
Political	90	80
Religious	20	30

*Significant points on the profile

The practical value of using most so-called personality tests has often been questioned, since their validity is dependent upon criteria which are usually difficult to establish At any rate if one attempts to go no further than to obtain a score for whatever a particular test tests, operational differences from one twin to the other can be established However, norms for most of these tests are sketchy and determinations of the probable error of a difference are almost impossible to obtain Hence the differences discovered here must be viewed with some reservations Widely divergent differences from one test to another are apparent for such traits as dominance-submission, but naturally it cannot be said that dominance or submission as measured by a test is anything more than what is included in the test The results of the tests used are included here in Table 5 They are stated in terms of the norms that have been established by the respective authors of the tests

On the Bernreuter *Personality Inventory*, the differences between the twins' raw scores were calculated and the difference in each case was divided by the *PE* of a difference, using the *PE*'s reported by Carter (7) None of these differences proved to be statistically significant For the other tests, no statistical norms were available, but the differences *appear* not to be very significant. On the whole these two twins showed remarkably similar performance on these tests

10 *Summary of Case 1*

A pair of female monozygotic twins, 20 years of age, were studied intensively by means of observation, interview, and the use of "standard" tests They proved undoubtedly to be more alike in physical appearance than the average set of identical twins Their environments have always been extremely similar, and their interests, attitudes, and trends of personality appear to be lacking in significant dissimilarities. A possible exception is in the degree of dominance. Intelligence tests uncovered no striking difference in degree of intellectual capacity.

C. CASE NO. 2

Twins *D.R.* and *E.R.* are both female and were 20 years of age at the time of the study. They were diagnosed as monozygotic by means of the techniques mentioned above. Here again the degree of physical similarity was sufficiently great as to make it impossible for this writer to tell the twins apart.

TABLE 6

PHYSICAL RESEMBLANCE OF THE TWINS

		D.R.	*E.R.*
Weight		137.5 lb	138.0 lb
Height		66 15/16"	67 11/16"
Sitting height		34¼"	35⅝"
Reach		65"	66"
Chest		32½"	33"
Waist		27"	26½"
Neck		13"	13"
Hips		37"	36"
Head circumference		21⅞"	21⅞"
Head length		18.38 cm.	18.85 cm.
Head width		14.05 cm.	14.56 cm.
Cephalic index		76.44	77.24
Eye color		Brown	Brown
Hair color		Brown	Brown
Bicep	R.	9¼"	9½"
	L.	9⅛"	9"¼
Wrist	R	6"	6"
	L	6"	6"
Ankle	R	7¼"	8"
	L	8"	8¼"
Calf	R	13½"	13½"
	L.	13½"	13½"
Thigh	R	19½"	19½"
	L	19"	19"
Grip (average of 3 trials)	R	*33.33*	*35.33*
	L.	*31.67*	*32.67*
*Tapping test (average of 3 trials of 30 seconds each)	R	226	181
	L	201	199
*Test of involuntary movement	R	7	5
	L	7	6
*Test of voluntary *movement* (average of 3 trials)	R.	*18 cm*	*15 cm*
	L	17 cm.	16 cm

*A description of these tests is given in Case No. 1

1. *Physical Similarities*

Close correspondence in physical measurements for this pair of twins is demonstrated by the values indicated in Table 6. These measurements show them to be even more nearly alike physically than *D. G.* and *L. G.*

2. *Finger and Palm Prints*

As in Case No. 1, the finger and palm prints were examined and found to be strikingly similar in pattern and design when cross-compared. The finger prints were evaluated by Bonnevie's technique, and the results are presented in Table 7. As before, the palm prints are included here to demonstrate the degree of similarity when cross-compared (Figure 2). Certain of the ridges have been darkened to bring out significant similarities.

TABLE 7

FINGER PRINT RAW RIDGE COUNT CLASSIFIED ACCORDING TO BONNEVIE'S METHOD (6)

	D. R.		*E. R.*	
	Right	Left	Right	Left
Thumb	2.5	1.0	2.5	2.5
Forefinger	1.5	1.0	2.0	1.0
Middle finger	1.5	1.0	1.0	1.0
Ring finger	4.0	3.0	4.0	3.0
Little finger	3.5	2.5	3.5	3.0
Total, each hand	13.0	8.5	13.0	10.5
Total, both hands	21.5		23.5	

In Case 1 the average differences and ranges in quantitative indices for the finger prints of Bonnevie's identical and fraternal twins are given. For *D. R.* and *E. R.* the differences in total quantitative values as indicated in Table 7 is 2.0, which is relatively near the lower limit for identical twins as determined by Bonnevie's data.

3. *Asymmetry*

On the few tests given where asymmetry could be observed, nothing definite was noticeable, although *E. R.* had a slightly better score with her left hand than with her right. The twins claim, however, that they are both right handed, and the superiority of *E. R.*'s scores for the left hand, while consistent, are not sufficiently greater than

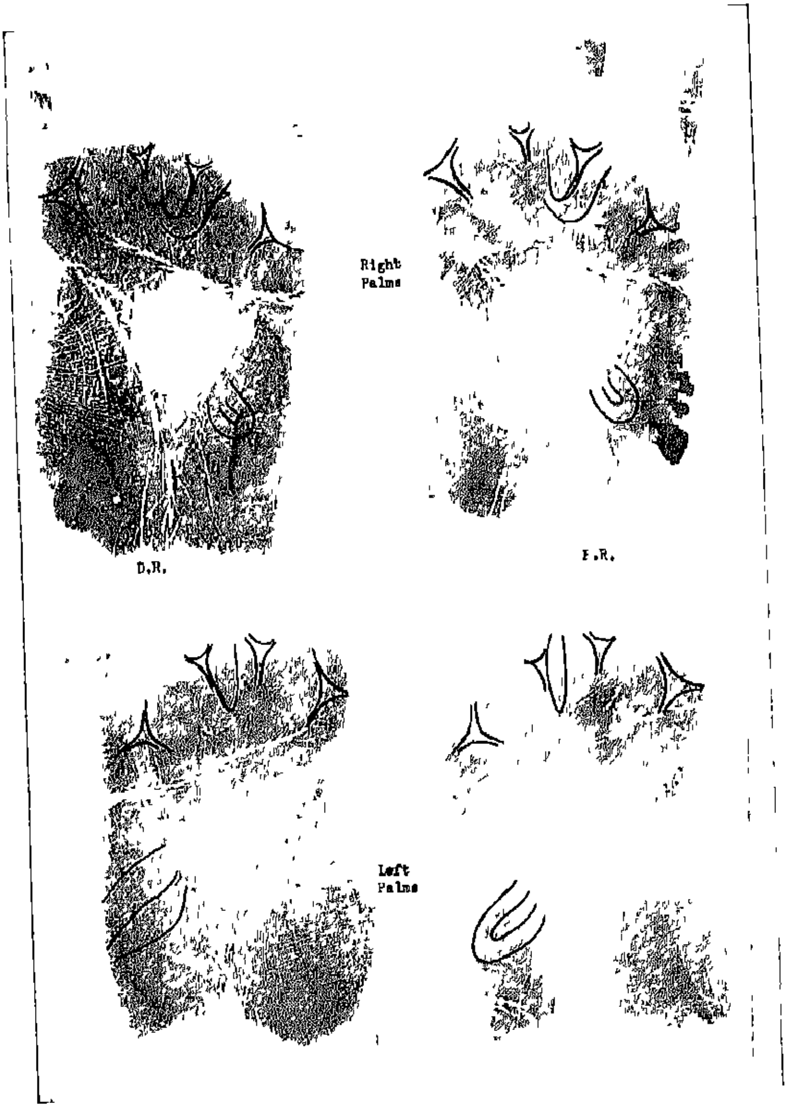


FIGURE 2

her scores for the right hand to warrant a conclusion of the presence of left handedness

4 *Developmental Data*

At birth the twins weighed a total of seven pounds, *D R.* weighing three pounds and *E R* four pounds. It is interesting to note that *E R* is slightly taller and heavier now than *D R*, a condition which has prevailed almost since birth, but the difference in weight is only a half pound and in height only three-quarters of an inch At the age of 11 both showed a very pronounced acceleration in growth, undoubtedly a normal epiphenomenon of approaching pubescence. Shortly after *D G*'s birth she had a stomach disease which was quite serious Both had the measles at about seven months of age, chicken pox at seven years, and whooping cough at nine years *E R* had her tonsils removed at five years of age There has been nothing particularly unusual about their development except as stated here As far as is known, it has been quite typical and normal

5 *Environment*

The twins' parents are American born, their father is 50 years of age, of German descent, has had civil engineering training, the mother is also 50 years of age, of French-American descent, a graduate of normal school and, prior to her marriage, a teacher The twins' only sibling is a brother, 23 years of age, who attends college. Their home is in a small town near New York City and the household is comprised of father, mother, older brother, and mother's mother. Their background is apparently of a substantial middle-class type

The twins do not believe they are of monozygotic origin and have been told otherwise by parents who wanted their children to have some individuality and not to be "just twins" Their parents have made every effort to develop each girl along lines pertaining to her special interests Despite this opportunity for divergent development, it is worth noting how similar are their interests and likes and dislikes They make no attempt to dress alike, but it is evident that they have similar tastes in clothes The twins have never been separated from each other for more than a single night at a time They are not solitary and do not run away from the company of others They are attractive girls and indulge in a whole-some, normal social existence, enjoying the companionship of people their own age. In high school *E.R.* went around with one boy quite steadily, but *D.R.* did not go out a great deal. In college, however, *D.R.* goes out quite often with young men; *E.R.* does not go out as often as she did in high school. It should be emphasized that in spite of a desire on the part of the parents to permit the twins to develop separately as would any two siblings, the twins have really had very similar environments, one small difference being the fact that *E.R.* has in the past led a more active social life.

6. *Personality Traits*

Both twins have very pleasing personalities, possessing a great deal of charm and poise. They are hard working and industrious. They both are working to help defray their college expenses, which shows a certain integrity of purpose. They are quite and unassuming and, in all respects, genteel and respectful. *E.R.* is apparently the more dominant and extroverted of the two. She seems to have more confidence and social presence in gregarious situations. However, from observation there are no striking differences in personality.

7. *Interests*

D.R. and *E.R.* have surprisingly similar interests despite their opportunity to develop along diverse lines. The two twins enjoy most forms of athletics, and are particularly interested in hiking and camping. They enjoy the usual college social functions and attend them regularly. With reference to vocational plans, *D.R.* wants to be a doctor. She works in a doctor's office apart from her college duties as a means of gaining preliminary "insight." *E.R.*'s desires are aimed at a position as a laboratory technician, and is taking courses in Physics and Biology in preparation for such a career.

8. *Measures of Intelligence and Mechanical Aptitude*

Results of the Kuhlmann-Anderson test are listed in Tables 8 and 9, a comparison of raw scores on different parts of the test being shown in Table 8 and Median Mental Ages and *IQ*'s in Table 9.

On the MacQuarrie test of mechanical aptitude *E.R.* proved superior to D.R., the former's mark placing her between the "high"

TABLE 8

COMPARISON OF THE RAW SCORES ON THE KUHLMANN-ANDERSON TEST

Test No.	*D.R.*	*E.R.*
24	8	9
25	9	6
26	14	15
27	21	20
28	12	10
29	12	11
30	14	12
31	12	13
32	9	5
33	12	12
34	13	20
35	17	10
36	9	7
37	17	17
38	7	3
39	7	6

TABLE 9

MEASURES OF INTELLIGENCE AND MECHANICAL ABILITY

Test	*D.R.*	*E.R.*
Kuhlman-Anderson—Median *MA*	17 yrs. 5 mo.	16 yrs. 3 mo.
IQ	108.9	101.6
MacQuarrie *Test for Mechanical Ability*		
Tracing	34	55
Tapping	57	49
Dotting	22	25
Copying	48	55
Location	29	35
Blocks	10	14
Pursuit	19	25
Total	219	258
Giving a score of	73	86
Percentile	13	39
Group represented by score	High average	High

and "very high" groups and the latter's mark placing her near the "high average" mark. The only part of this test on which *D.R.* surpassed *E.R.* was in tapping, and she claims this is probably due to practice in stippling necessary in biological work. The results of this test are listed in Table 9.

TABLE 10

RESULTS OF PERSONALITY TESTS

Test	*D R*	*E R*
Moss, Hunt, Omwake—*Social Intelligence Test*		
1 Judgment in social situations	29	25
2 Recognition of the mental state of the speaker	30	26
3. Observation of human behavior	46	38
4 Memory for names and faces	24	22
5 Sense of humor	16	17
Total score	145	128
Percentile	90	70
Allport and Allport *A-S Reaction Study Score*	+6	+25
Decile	7	4
Interpretation	First degree of submission	First degree of ascendance
Laird *Personal Inventory C-2 Score*	11	11
Interpretation	More introverted than 4% of women	More introverted than 4% of women
Bernreuter *Personality Inventory*		
Percentiles		
B-1N (Neurotic tendency, low score means well balanced)	16.4	0.0
B2-S (Self-sufficiency, high score means self-sufficiency)	38.6	79.8
B3-I (Introversion-extroversion, high score means introverted)	7.0	0.0
B4-D (Dominance-submission, high score means dominant)	63.2	94.6
F1-C (Self-confidence, low score means great self-confidence)	11.6	0.0
F2-S (Sociability, high score means non-social)	21.6	49.0
Hum-Wadsworth *Temperament Scale*		
Normal	+2*	0
Hysteroid	—1	+1*
Cycloid manic	+2*	+2*
Cycloid depressive	—1	—1
Schizoid autistic	0	—2
Schizoid paranoid	—3	+1*
Epileptoid	—3	—1
Bell *Adjustment Inventory*		
Home adjustment	excellent	excellent
Health adjustment	good	excellent
Social adjustment	average	excellent
Emotional adjustment	good	excellent
Total adjustment	average	excellent

TABLE 10 (*continued*)

Test	D R.	E R
Allport-Vernon *Study of Values* (Percentiles)		
Theoretical	50	40
Economic	20	50
Aesthetic	10	50
Social	80	70
Political	80	20
Religious	90	50

*Significant points on the profile.

9 *Tests of Personality Traits*

The results of the tests used are arranged in Table 10 Norms are given wherever possible

Whereas observation and interview uncovered no striking differences in personality trends, some of the results of tests tabulated above exhibit marked dissimilarities Again using the *PE*'s reported by Carter (7), statistically significant differences were found in the *B2-S* (self-sufficiency) and the *B4-D* (dominance-submission) scales, of the Bernreuter test. These showed *E R.* to be significantly more self-sufficient than *D R.* and more dominant. Although no *PE* of a difference is available for the *F1-C* (self-confidence) scale, the difference shown of 83 points (raw score difference) would undoubtedly prove of significance and show *E R* to be more self-confident Other differences appear in the social intelligence test, in the Allport *A-S Reaction Study*, in the Humm-Wadsworth scale, in the Bell-Adjustment *Inventory*, and in the Allport-Vernon *Study of Values*

10 *Summary of Case 2*

Here we have a pair of twins, apparently of monozygotic origin, who are extremely similar physically, but who differ quite significantly in *IQ* as determined by the Kuhlmann-Anderson test, in mechanical ability, and in various aspects of personality To attempt to account for the dissimilarities would be impossible because of the complexity of determining factors The writer can here but reiterate the fact that he is reasonably certain of the single-egg origin of these twins, and will permit others to speculate on the causes of the differences between these two It should be remembered that their environmental contacts have been closely alike

D. CASE NO 3

Twins *G.L* and *M L.* are both male and were 21 years of age at the time of this study. They were diagnosed as monozygotic by means of the techniques previously mentioned. Again the degree of physical similarity was very pronounced, making it impossible for the author to tell the twins apart. There is additional evidence which this writer believes may be construed as supporting a diagnosis of monozygosity When the twins were 15 years of age and seniors in high school, a peculiar condition developed in the right arm of each twin Apparently the muscles from the elbow to the wrist in the right arm of each began to atrophy. They have been observed and given many tests by a prominent nerve specialist who was unable to state the cause or the real nature of the condition It is apparently a case without known precedent, but it is especially significant that the same thing occurred in both twins at the same time. Their scores in the strength of grip test show this deficiency of muscular strength in the right arm (recorded in Table 11). Strangely enough, in the few months just prior to this study the same condition began to set in in the left arm of each twin

1. *Physical Similarities*

In this study, as in the previous two, close physical resemblance is quite apparent. The only sizeable difference is that *M L* has a cephalic index of 77.05 and *G L.* one of 73 98. This would place *M.L.* in the so-called mesocephalic class and *G.L.* in the dolichocephalic class. While this difference in the shape of the head is present, it is not noticeable when looking at them in an attempt to distinguish one from the other

2. *Finger and Palm Prints*

As in the previous cases, the finger and palm prints were strikingly similar in pattern and design when cross-compared The finger prints, evaluated by Bonnevie's technique, are given in their quantified form in Table 12. The palm prints are included as a means of showing more concretely the remarkable cross-comparison similarities (Figure 3).

The difference of 3 0 in total quantitative value of finger prints as shown in Table 12 is relatively near the lower limit for identical twins as shown by Bonnevie's data.

TABLE 11
Physical Resemblance of the Twins

		G L.	*M L*
Weight		169 lb	165 lb
Height		67¼"	67¼"
Sitting height		35"	35"
Reach		70½"	70½"
Chest		37"	37¼"
Waist		35"	34"
Neck		15½"	15¼"
Hips		39"	39"
Head circumference		23¼"	24⅛"
Head length		20.68 cm	20.48 cm.
Head width		15.30 cm	15.78 cm
Cephalic index		73.98	77.05
Eye color		Blue	Blue
Hair color		Brown	Brown
Bicep	R	13¼"	13"
	L	13½"	13¼"
Wrist	R	7¼"	7"
	L	7½"	7¼"
Ankle	R	10¼"	10½"
	L	10¼"	10½"
Calf	R	15"	15½"
	L.	15"	15½"
Thigh	R	21"	21½"
	L	21"	21½"
Grip (average of 3 trials)	R	12.33	25.00
	L	39.00	43.33
*Tapping test (average of 3 trials of 30 seconds each)	R	210	180
	L	180	180
*Test of involuntary movement	R	7	6
	L	6	6
*Test of voluntary movement (average of 3 trials)	R	21 cm	13 cm
	L	13 cm	7 cm.

*See Case No. 1 for descriptions of these tests

3. *Asymmetry*

Both twins are right handed and neither claims to have had any childhood tendency to be ambidextrous or left handed. Their right handedness is brought out in the results of the various tests of motor coordination as listed in Table 11. However, *M L* had the same score for both hands on the Tapping Test and Test of Involuntary Movement. No real significance can be placed in this, since the tests were not adequate as a measure of asymmetry, they were used merely to compare one twin with the other.

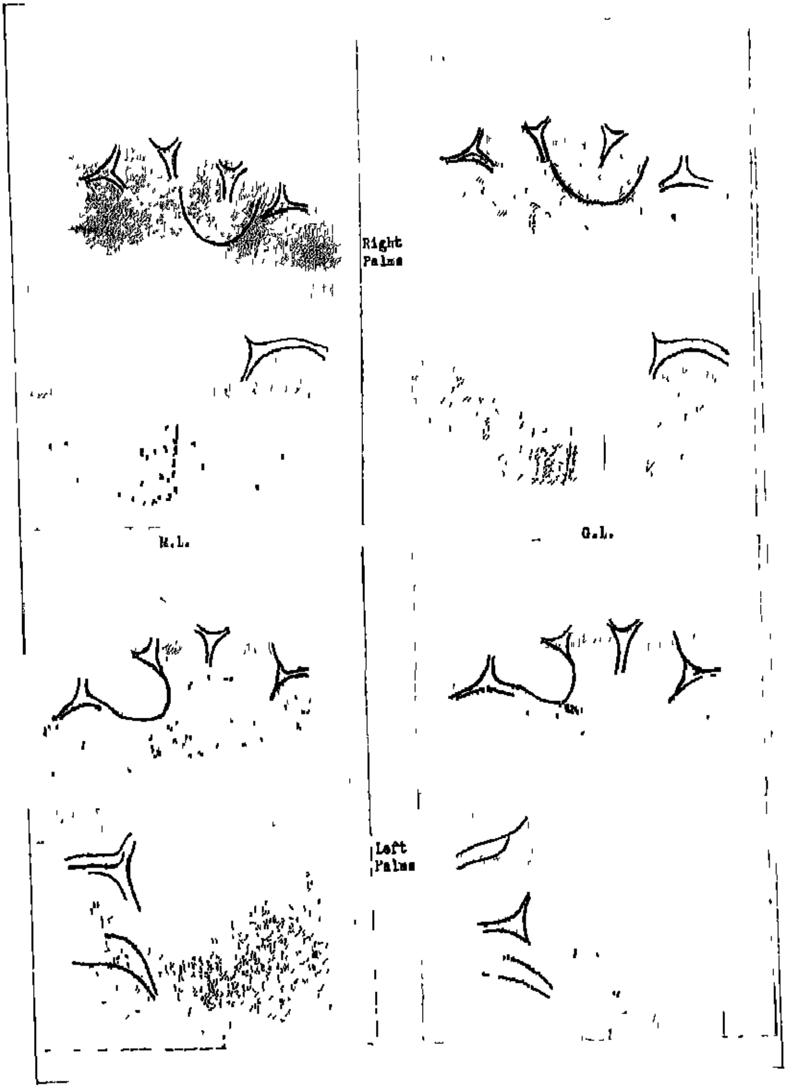


FIGURE 3

TABLE 12

FINGER PRINT RAW RIDGE COUNT CLASSIFIED ACCORDING TO BONNEVIE'S METHOD (6)

	G L		M L	
	Right	Left	Right	Left
Thumb	9.0	4.5	9.5	5.0
Forefinger	6.0	3.5	6.5	4.0
Middle finger	6.0	3.5	6.5	3.5
Ring finger	8.0	3.0	7.5	4.0
Little finger	4.0	3.5	4.0	3.5
Total, each hand	33.0	18.0	34.0	20.0
Total, both hands	51.0		54.0	

4. *Developmental Data*

M L was born a half hour before *G L.* and weighed 6¾ pounds as compared to *G.L* who weighed 6½ pounds *M L* has always been slightly taller and weighed a few pounds more than *G L* *G.L* had scarlet fever at four years of age and *M L.* had the same disease when he was 14 At seven years of age both had whooping cough, at eight they both had mumps, at nine chickenpox; at 10 measles Both have otherwise been in good health except for the muscular ailment mentioned before

5 *Twins in the Family*

In the last three generations there have been three sets of twins in the family, one, a set which were first cousins of the twins' father and who were of unlike sex, one male and the other female, and two other sets of twins whose probable origin is not known, i.e., whether or not they were monozygotic

6 *Environment*

The twins' father is a high school teacher and has had a college education He is a Protestant and has no particularly bad habits. The mother is 58 years old, and went as far as the second year of high school The twins have two male siblings both quite a bit older than the twins, one being 32 and the other 33 years of age at the time of this study. They have both had college educations. The home life is quite typical of middle class comfort They own their own home, are self supporting, and suffer no essential wants The twins, when younger, had many childhood companions and always played together with the same friends. They have never been separated from each other for more than a week at a time and neither has encountered any striking experiences not shared by the other. *G.L.* and *M.L.* have always been together in the same grade in school and at present room together in college, take the same courses, and assist each other in their laboratory work. They have thus had quite similar environmental backgrounds.

7. *Personality Traits*

M.L. and *G.L.* are both exceptionally intelligent in their work, but *M.L.* is more of a "plugger," and *G.L.* more content to take things easy *M.L.* is more inclined to introvertive pursuits while *G.L.* is more social and "dates" quite often. It has been two years since *M.L.* has been out in the company of a young lady. The twins are not especially handsome, and make a first impression of being surly, they are, however, when one becomes better acquainted, both pleasant and agreeable. *G.L.* is the more extroverted and dominant of the two as attested by various friends of the twins, and *M.L.* is shy, seclusive, and quiet. Both boys work to earn part of their college expenses. *M.L.* does some tutoring work and *G.L.* works in the dormitory kitchen These occupations are not matters of choice or interest, but merely jobs that were available.

8. *Interests*

Their interests are for the most part the same Both intend to teach Physics and Chemistry in high school. Their likes and dislikes are similar and show no divergence except that *G.L.* likes social affairs and the company of members of the opposite sex, while *M.L.* does not Neither has any particular hobby or avocation.

9 *Measures of Intelligence and Mechanical Aptitude*

Results of the Kuhlmann-Anderson test are listed in Tables 13 and 14, a comparison of raw scores on different parts of the test being shown in Table 13 and Median Mental Ages and *IQ* in Table 14

M.L., whose *IQ* (see Table 14) is about two points lower, was elected to Phi Beta Kappa and *G.L.* was not. Although *G.L.*'s average has been just two points lower than *M.L.*'s consistently for a period of eight years, his college record was just below, and *M.L.*'s

TABLE 13

Comparison of the Raw Scores on the Kuhlman-Anderson Test Results of Personality Tests

Test No.	G L	M L.
24	6	7
25	10	9
26	15	15
27	27	28
28	12	10
29	11	9
30	14	14
31	15	15
32	14	11
33	14	15
34	20	20
35	14	18
36	10	10
37	19	20
38	9	8
39	7	7

TABLE 14

Measures of Intelligence and Mechanical Ability

Test	G L	M L
Kuhlmann-Anderson—Median *MA*	19 yrs 11 mo	19 yrs 8½ mo
IQ	124.5	122.6
MacQuarrie *Test for Mechanical Ability*		
Tracing	33	30
Tapping	38	45
Dotting	19	20
Copying	43	40
Location	25	34
Blocks	10	15
Pursuit	20	24
Total	188	208
Giving a score of	63	69
Percentile	62	51
Group represented by score	Low average	Average

just above, the average required by Phi Beta Kappa. This shows the results apparently of *G L.*'s greater interest in things social and his lesser application to intellectual pursuits. The difference, however, is not really significant.

The scores on the MacQuarrie test of mechanical ability differed

TABLE 15

RESULTS OF PERSONALITY TESTS

Test	G L	M L
Moss, Hunt, Omwake—*Social Intelligence Test*		
1 Judgment in social situations	27	28
2 Recognition of the mental state of the speaker	28	28
3 Observation of human behavior	48	41
4 Memory for names and faces	13	19
5 Sense of humor	19	17
Total score	135	133
Percentile	80	80
Allport and Allport *A-S Reaction Study* Score	+3	—5
Decile	5	7
Interpretation	Average	First degree of submission
Laird *Personal Inventory C-2* Score	11	14
Interpretation	More introverted than 32% of men	More introverted than 57% of men
Bernreuter *Personality Inventory* Percentiles		
B1-N Neurotic tendency, low score means well balanced)	20.0	69.8
B2-S (Self-sufficiency, high score means self-sufficient)	27.8	20.4
B3-I (Introversion-extroversion, high score means introverted)	12.2	54.6
B4-D (Dominance-submission, high score means dominant)	60.4	17.8
F1-C (Self-confidence, low score means great self-confidence)	40.4	81.8
F2-S (Sociability, high score means non-social)	19.6	58.4
Humm-Wadsworth *Temperament Scale*		
Normal	+2*	+2*
Hysteroid	0	—1
Cycloid manic	0	—1
Cycloid depressive	0	—1
Schizoid autistic	—1	+1*
Schizoid paranoid	—2	—2
Epileptoid	—2	—1
Bell *Adjustment Inventory*		
Home adjustment	*excellent*	*excellent*
Health adjustment	average	good
Social adjustment	unsatisfactory	unsatisfactory
Emotional adjustment	average	average
Total score	33	33
Total adjustment	average	average

TABLE 15 (*continued*)

Test	G.L.	M.L.
Allport-Vernon *Study of Values* (Percentiles)		
Theoretical	30	70
Economical	70	60
Aesthetic	5	10
Social	90	50
Political	90	90
Religious	90	70

*Significant points on the profile

somewhat, enough so that *G.L.* was placed in the "low average" group and *M.L.* in the "average" group according to the norms set up by the author of the test. *G.L.* surpassed *M.L.* on only two parts of the test, those of tapping and copying.

10. *Tests of Personality Traits*

The same tests given to the first two sets of twins were given to this pair. Results are tabulated in Table 15, giving norms wherever possible.

The tests in Table 15 corroborate the observational evidence and show *M.L.* to be the more introverted of the two. Statistically reliable differences are found, using the *PE*'s of Carter (7), in neurotic tendency, introversion, and dominance as defined by the Bernreuter test. In these three *M.L.* proved to be more neurotic, more introverted, and more submissive, characteristics which, by popular definition, can also be shown to be present. *M.L.* also shows a "high point" for "schizoid autistic" on the Humm-Wadsworth scale. It is likely also that, if *PE*'s were available, significant differences would appear in the self-confidence and sociability scales of the Bernreuter, showing *M.L.* to be less self-confident and more non-social.

11. *Summary of Case 3*

This pair of twins, although extremely similar in physical appearance and measurements, and obtaining nearly the same *IQ* on the Kuhlmann-Anderson test, showed a definite divergence in the trend of personality development. Many writers on twins have shown that more often than would be expected identical twins vary in this respect. To be sure this has been true of the other two sets of twins studied here, but the difference was not so clear cut and clinically apparent as in this case. There were no upsetting discrepancies from one test to another, only clear consistency which makes the divergence all the more certain.

E. SUMMARY, SUGGESTIONS, AND CONCLUDING REMARKS

Having recognized the desirability for gathering intensive data on single sets of twins as they become available, three sets of twins, diagnosed by reliable methods as monozygotic, were studied. Anthropometric measures, tests of physical skill, measures of intelligence and various tests measuring, in an operational sense, certain aspects of personality were made mainly for the purpose of demonstrating differences in behavior, in each case, of two individuals who were born with the same set of hereditary characteristic determiners and who have lived under strikingly similar environmental conditions. If Mendelian postulates are to be regarded as reliable, then the diversities in performance that were uncovered must be interpreted in terms of the small, almost intangible, environmental differences that existed in each instance. Since it is impossible to unscramble these differences, any just conclusions from such data must await the eventual amassing of a great many such studies and their statistical analysis, safe in the security of numbers.

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STUDIES IN ANIMISM II THE DEVELOPMENT OF ANIMISM*[1]

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A INTRODUCTION

Interest in the experimental study of child animism received considerable impetus from Piaget's two 1926 publications (6, 7) His theoretical views as expressed in these volumes are based upon a wealth of detailed facts obtained from children's responses to experimental questions, as well as upon their spontaneous behavior under certain conditions of observation. However, these data are not sufficiently quantitative to allow for statistical analysis and, on this score, have been subjected to considerable criticism (2, 3, 4, 5). The critics themselves, on the other hand, have not seen fit to establish quantitatively their argument and the point still remains in dispute

Piaget conceives of animistic development in the child as characterized by certain definite stages. Children in the first stage consider anything as living which is of some use or is in good condition, i e , not broken, damaged nor separated from its normal context In the second stage anything that moves is considered living This is in contrast to the more restricted third stage in which the child distinguishes spontaneous movement from movement imposed by an outside agent, life being identified with spontaneous movement In the fourth, or adult, stage life is restricted either to animals or to animals and plants.

The temporal course of these stages has been expressed by Piaget in the following statements (9, 537-538)

> 1. "For children between four and six everything . . is alive" (*Stage 1*)

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[1] This work was conducted under the direction of Dr Wayne Dennis while the writer was Du Pont Research Fellow in Psychology at the University of Virginia

> 2 "Children of six and seven call what moves alive in contrast to what is inert" (*Stage 2*)
>
> 3. "From eight to ten years a new distinction arises, that of original and acquired movement. To be alive is to move of oneself" (*Stage 3*)
>
> 4. "Finally, at about eleven the child reserves life to animals and plants, or even to animals alone" (*Stage 4*).

It is the purpose of this paper to present an experimental study of child animism sufficiently objective to establish quantitatively its developmental course.

B METHOD

A standardized method has been described by Russell and Dennis (10) which makes it possible to classify children into the four stages of animism outlined by Piaget and, by so doing, permits an objective study of the development of animism. This method has been employed throughout the present investigation.

The procedure consists in individually questioning each subject concerning the animate or inanimate nature of a series of objects which have been chosen with a view to determining the position of the child in the scale of animistic concepts. Additional questioning to supplement the original responses when the latter are not clearly intelligible is provided for. Precautions have been taken to guard against the discrepancies arising from subjective classification of responses obtained by the method

The reliability of the method as expressed by the coefficient of mean square contingency for examination-re-examination scores was found to be 0.81 (this value cannot be expected to exceed 0.91 with a 6 x 6 contingency table)

C SUBJECTS

A total of 774 children were studied during the progress of the experiment Of these 361 were enrolled in the "*F*" Primary School in Worcester, Massachusetts, a city of approximately 200,000 inhabitants. The majority came from lower middle class homes, and from English-speaking parentage. Those examined comprised the complete enrollment of the school and were distributed about evenly among the various grades. The range in *CA* was from 6 years 0 months to 15 years 6 months. In the school curriculum some nature study was a part of the subject matter of the higher grade pupils, but such special instruction was not emphasized. The children as a whole had little opportunity to observe nature at first hand in the manner which is available to all rural children.

The other 413 subjects comprised the first to seventh grades (inclusive) of the *"Mc"* school in Albemarle County, Virginia. They were separated into two groups, for convenience referred to as the *"S"* and *"R"* groups, on the bases of residence within or outside of the suburbs of the city of Charlottesville. At the beginning of our study, all of the subjects lived beyond the city limits of Charlottesville. However, during the progress of the experiment changes in the city limits occurred which resulted in the inclusion in the city of the above mentioned "suburban" areas, leaving thinly-settled or "rural" districts unannexed. The separation into groups was accomplished on the basis of the new city limits.

As in the case of the *"F"* group nature study was not emphasized in the school curriculum. However, since these subjects all resided in areas of considerably less dense population than did the *"F"* group, it was to be expected that their contacts with natural phenomena would be more numerous. Of the *"S"* group 70 per cent reported having either flower or vegetable gardens at home, while 83 per cent reported animals or pets of some kind. In the *"R"* group the percentages were somewhat higher as might be expected, being 87 per cent and 95 per cent respectively. While such data were not obtained from the Worcester subjects, it is known that gardens were very few in number and pets were far from common.

After the examination for animism was completed the subjects were given Kuhlmann-Anderson *Intelligence Tests*. Due to absences on the day of the administration of the tests, mental ages were determined for only 663 of the subjects. Table 1 presents the median *IQ*'s, the standard deviations of the distributions and the ranges in *IQ* values for the three experimental groups.

TABLE 1

RESULTS FROM THE KUHLMANN-ANDERSON INTELLIGENCE TESTS FOR THE THREE EXPERIMENTAL GROUPS

Group	Median *IQ*	σ_{dis}	Range
"F"	106.05	9.00	75 to 139
"S"	96.90	14.24	52 to 130
"R"	90.50	14.17	52 to 131

D. Results

1. *Classification into Stages*

Of the 774 children examined only 10 had systematic distinctions between the *animate and* the inanimate which were not in accord with any of the four stages. This means that of all the subjects other than those in the *No Concept Stage* (*NC*), of which there were 57, only 1.5 per cent did not definitely fall into one or other of the designated stages. For convenience of description in the remainder of the paper this 1.5 per cent is referred to as being in a *"Special Concept"* (*SC*) stage.

2. *Progression of Stages*

Figures 1 and 2 and Tables 2 and 3 show the percentage of cases in each stage of concept for two-year periods from mental and chronological ages of 6 years 0 months to 13 years 11 months.

From Figure 1 it is apparent that the stage containing the highest

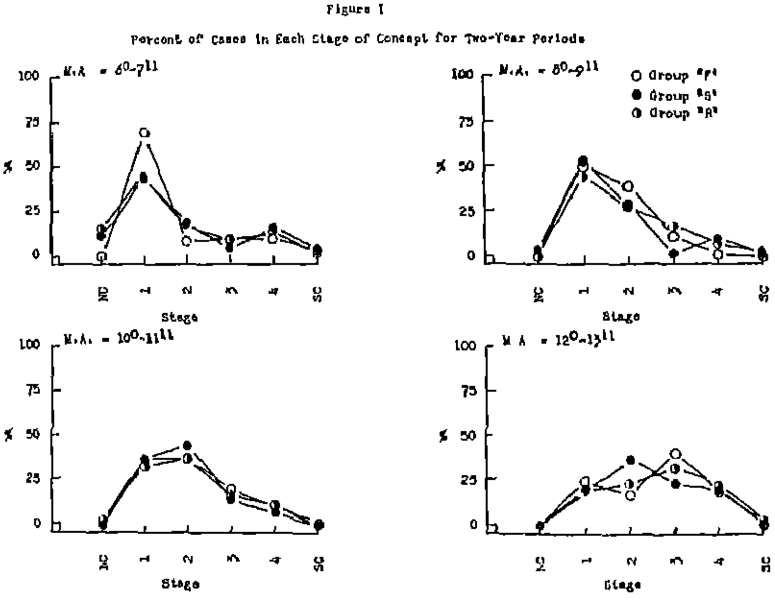

FIGURE 1

Per Cent of Cases in Each Stage of Concept for Two-Year *MA* Periods

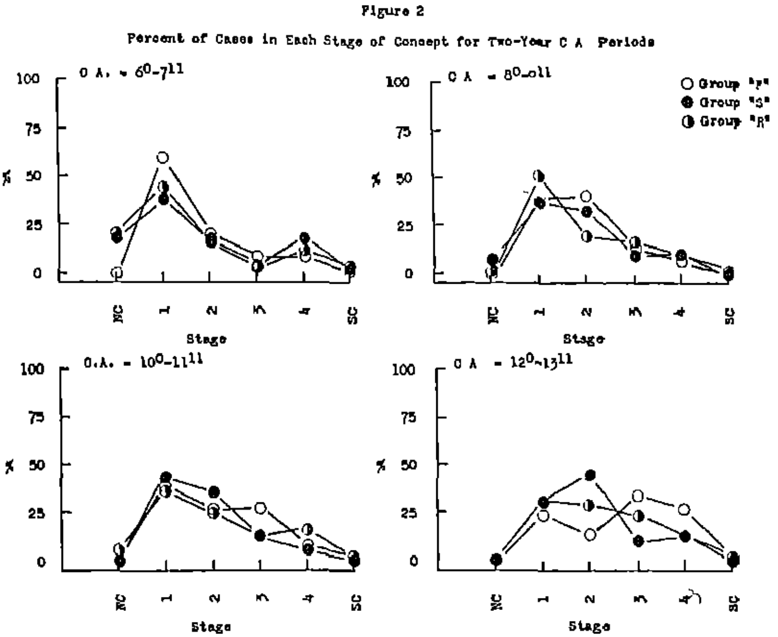

FIGURE 2

PER CENT OF CASES IN EACH STAGE OF CONCEPT FOR TWO-YEAR *CA* PERIODS

TABLE 2

PER CENT OF CASES IN EACH STAGE OF CONCEPT FOR TWO-YEAR *MA* PERIODS

Group	*MA*	*NC*	1	2	3	4	*SC*
"F"	6°- 7″	0	69	8	10	10	3
	8°- 9″	0	50	38	11	1	0
	10°-11″	0	33	37	19	10	1
	12°-13″	0	24	17	40	18	1
"S"	6°- 7″	12	43	19	5	16	5
	8°- 9″	4	53	29	2	10	2
	10°-11″	0	36	44	13	7	0
	12°-13″	0	20	37	23	20	0
"R"	6°- 7″	15	44	18	8	13	2
	8°- 9″	0	44	28	17	8	3
	10°-11″	2	36	36	16	10	0
	12°-13″	0	19	23	32	23	3

TABLE 3

Per Cent of Cases in Each Stage of Concept for Two-Year *CA* Periods

Group	*CA*	*NC*	1	2	3	4	*SC*
"*F*"	6°- 7"	0	61	20	9	9	1
	8°- 9"	0	40	41	13	7	0
	10°-11"	0	38	27	27	8	0
	12°-13"	0	24	13	34	27	2
"*S*"	6°- 7"	18	38	18	5	18	3
	8°- 9"	8	37	33	10	10	2
	10°-11"	0	44	36	13	6	1
	12° 13"	0	31	45	11	13	0
"*R*"	6°- 7"	20	44	16	4	12	4
	8°- 9"	2	51	20	17	10	0
	10°-11"	6	37	25	13	17	2
	12°-13"	0	31	30	21	13	2

percentage of cases increases with increasing mental age, despite the fact that each concept stage covers the entire age range This relationship holds for all three groups studied in spite of their varied geographical locations and socio-economic status Of considerable interest is the fact that not only is the progression similar for the three groups, but it is very nearly the same in terms of percentages in each stage at each age interval, the only significant difference between the groups being in the 6°-7" mental age interval at the Stage 1 level. In this latter instance the "*F*" group exceeds the "*S*" and "*R*" groups, compensation for this difference being at the *NC* and Stage 2 levels.

The progression is not as clearly distinguishable in the case of the chronological age range (Figure 2). However, it is apparent that the per cent of cases in the more advanced stage levels increases with increasing age. The three experimental groups reveal a close similarity as in the case of the mental age comparisons mentioned above. The greatest differences in this instance occur in 6°-7" age interval at the Stage 1 level and in the 12°-13" age interval at the Stage 2 level In neither case are the differences between the most widely different groups reliable, as is shown by critical ratios of 2.24 and 2.51 respectively.

It might appear paradoxical that groups with significantly different median *IQ*'s should not reveal significant differences where the correlations of stage and mental age, and stage and chronological age are 0.50 and higher (see correlations given below) This lack of significant differences might not exist if the number of cases were greater On the other hand, where the differences are great enough to approach significance they favor the "*F*" group as being more advanced This latter fact is apparent from an examination of Figure 2, particularly at the 12°-13" age interval in Stages 3 and 4

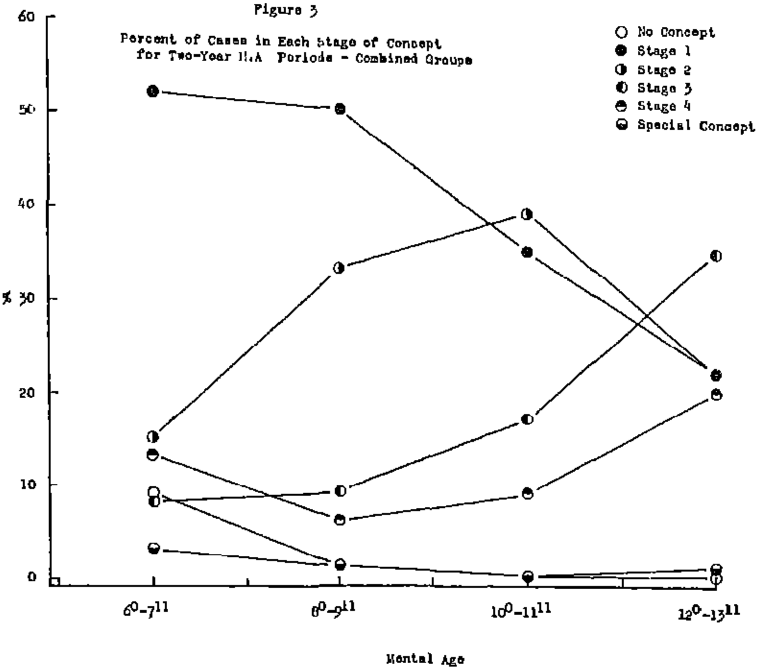

FIGURE 3
PER CENT OF CASES IN EACH STAGE OF CONCEPT FOR TWO-YEAR *MA* PERIODS COMBINED GROUPS

TABLE 4
PER CENT OF CASES IN EACH STAGE OF CONCEPT FOR TWO-YEAR *MA* PERIODS—COMBINED GROUPS

MA	*NC*	1	2	3	4	*SC*
6°- 7"	9	52	15	8	13	3
8°- 9"	1	50	33	9	6	1
10°-10"	0	35	39	17	9	0
12°-13"	0	22	22	35	20	1

Figure 3 and Table 4 present the data for the combined groups. In these instances the per cent of cases in the combined experimental groups in each stage of concept is given as a function of mental age at two-year levels. It is at once apparent that there is a progression of stages with increasing age. Within the age limits represented both the *No Concept Stage* and Stage 1 begin at a peak and diminish with increasing age; Stage 2 increases until a maximum is reached and then declines, while both Stage 3 and Stage 4 progressively increase, the former distinctly preceding the latter. This evidence, combined with the manifestations of animistic development revealed by the study of the individual group data, leaves no question as to the validity of the progression of stages in the experimental groups.

Emphasis should be placed on the complete coverage of the entire mental age range by all the concept stages. This is particularly significant in view of Piaget's statement of the temporal course of animism quoted above. Our results indicate the impossibility of a sharp successive delineation of animistic stages such as that suggested by Piaget.

3. *Correlation of Stage with MA and CA*

If an increasing age is coincident with a developing concept, as the above considerations would tend to indicate, we should expect a significant correlation between age and stage in spite of the complete coverage of concept stages. Table 5 presents the correlations

TABLE 5
COEFFICIENTS OF MEAN SQUARE CONTINGENCY FOR THE RELATIONSHIPS BETWEEN *MA* AND *CA* AND STAGE FOR THE EXPERIMENTAL GROUPS

Group	*MA*	*CA*
"*J*"	0.54	0.73
"*S*"	0.60	0.49
"*R*"	0.58	0.57
Combined groups	0.59	0.62

between both mental and chronological ages and stage for the three experimental groups and the combined groups.

It will be noticed that, in the main, the coefficients are of a similar order of magnitude, which, although not significant for individual prediction, do reveal a decided tendency toward a group relationship

4 *Correlation of Stage with Grade in School*

Since the stage of concept does not correlate more highly with mental and chronological age, it might be that the development of animism is more closely dependent upon experience gained through progress in school. If this were the case, coefficients of mean square contingency between stage and school grade should be high. However, the coefficient for the *"F"* group is 0 45; for the *"S"* group, 0 48; and for the *"R"* group, 0 43 Again the correlations are too low to be significant for individual prediction, but, in this instance, they reveal even a weaker tendency toward a group relationship than did the correlations of stage with *MA* and *CA*

5. *Sequential Development within the Individual*

So far we have dealt with the problem of the development of animism only in terms of group comparisons. However, an equally important question concerns the development of animism as a function of increasing age within *single* individuals Data pertaining to this aspect of the problem have been obtained by the re-examination of individual subjects in some cases at one week and in other cases at three months after the original examination

One hundred and thirty-three subjects of the *"F"* group, consisting of those children who entered each grade in September,[2] were arbitrarily chosen for re-examination after a period of one week An analysis of the data shows that 18 per cent of the subjects advanced on their retest, 9 per cent regressed and 73 per cent remained at the same level Russell and Dennis (10) have discussed a possible explanation for the regressions At present we are interested mainly in the fact that of those who advanced, 81 per cent advanced by one stage, 14 per cent by two stages and 5 per cent by three stages and, of these who regressed, 77 per cent regressed by one stage, 23 per cent by two stages and 0 per cent by three stages

All subjects in the *"S"* and *"R"* groups, with the exception of 88 absentees, were re-examined three months after the original examination. Table 6 shows the per cent of progressions and regressions for the *"S"* and *"R"* groups combined.

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[2] Each grade was divided into two groups, those entering in February and those entering in September

TABLE 6*

PROGRESSIONS AND REGRESSIONS AS REVEALED BY RE-EXAMINATION THREE MONTHS AFTER THE PRIMARY EXAMINATION—COMBINED *"S"* AND *"R"* GROUPS

Progressions				Regressions			
1 Stage	2 Stages	3 Stages	4 Stages	1 Stage	2 Stages	3 Stages	4 Stages
54%	34%	9%	3%	77%	15%	8%	0%

*Of the combined "S" and "R" groups 36 per cent changed from examination to re-examination, 33 per cent of these regressing and 67 per cent progressing, while 64 per cent remained the same. The greater per cent of change in these groups as compared with the *"F"* group is to be expected *since the interval between examination and re-examination was three months* as compared with one week.

From the percentages given in Table 6 it is clear that, when an individual changes, the chances are great that the change will be only one stage, whether it be above or below his previous concept level. In the few instances where changes greater than one stage do occur it may be that the time interval between examination and re-examination has been sufficiently long for the individual to develop through more than one stage. This would picture the individual as passing from one stage to another *in an orderly fashion* even though he remains for varying lengths of time at each stage level. However, regardless of speculation as to an explanation of the few cases in which there is a change of more than one stage level *on re-examination*, the great predominance of cases showing changes of one concept level only tends to indicate that in studying the animistic stages we are dealing with a *real* scale. By a *real* scale we are referring to one on which any change of more than one unit necessarily means a traversal of the intervening unit or units *during the process of the change*.

All these facts lead us to stress the *probability that, in terms* of the animistic scale, individuals do pass sequentially through the series of concept stages with increasing mental and chronological age. However, the fact must be recognized that an absolutely concrete *proof could only* be obtained by a longitudinal survey of animistic stages throughout their *development in single individuals*

6 *Sex Differences*

An analysis of the data on the basis of sex reveals no significant differences between the male and female subjects in any of the three groups. Table 7 presents the per cent of male and female cases in each stage of concept for two-year mental age periods.

TABLE 7

PER CENT OF MALE AND FEMALE CASES IN EACH STAGE OF CONCEPT FOR TWO-YEAR *MA* PERIODS—COMBINED GROUPS

MA	*NC*	1	2	3	4	*SC*
			Male			
6°- 7″	3	52	17	7	9	2
8°- 9″	1	43	33	14	8	1
10°-11″	1	30	40	18	11	0
12°-13″	0	18	26	37	14	5
			Female			
6°- 7″	14	51	13	10	7	5
8°- 9″	1	59	32	4	3	1
10°-11″	0	36	38	16	10	0
12°-13″	0	26	20	33	11	0

7 *The Universality of the Stages of Animism*

Piaget's studies previously referred to were conducted on a group of French-speaking children, the exact number of which is not revealed

The present study deals with three distinctly different groups of children, a Northern "urban" group, a Southern "suburban" group and a Southern "rural" group. Yet evidence has been presented which indicates that, in spite of their diversities, subjects in these three groups are readily classified into stages of animism on the same basis as those employed in Piaget's French group

Data are also available for 33 first to fourth grade children in a small private school in Massachusetts. The average *IQ* for this group is 121 and the group as a whole has had the advantages of specific nature studies. In both these latter regards they are more nearly similar to Isaacs' group (Mental Ratio = 131) than any of the other groups studied Analysis of the responses of these children, while not allowing for statistical treatment, due to the lack of a sufficient number of cases, still reveals an ease of classification into stages of animism

Further evidences for the universality of the stages of animism were found by Dennis (1) in an unpublished study of Zuni and Navaho children living on Indian reservations in the American Southwest. Twenty-eight responses to the standardized series of questions previously described by Russell and Dennis (10) were obtained and were readily classified into stages on the same basis as employed in the other studies here mentioned.

Finally, Russell, Dennis, and Ash (11) have found abundant evidence among feeble-minded subjects of the development of a series of concept stages identical to the series found in the present studies of normal children

Certainly the division of animistic development into the stages suggested by Piaget cannot be questioned in the face of such a wealth of evidence from diverse sources.

E CONCLUSIONS

From a consideration of the results the following conclusions seem warranted:

1 *It is possible to classify individuals into the stages of animism suggested by Piaget.* This conclusion is substantiated by the facts that· (*a*) 98.5 per cent of the subjects studied were readily classifiable into one or other of the stages of animism, and (*b*) evidence for the universality of such a classification has been drawn from the examination of French children (Piaget), American Urban, Suburban and Rural children (Russell), children of high mental ability and special nature training, American Indian children (Dennis), and feeble-minded subjects (Russell, Dennis and Ash)

2 *It is probable that individuals pass sequentially through the series of concept stages with increasing mental and chronological age.* Evidence for this conclusion lies in the fact that. (*a*) curves for the per cent of cases in each stage of concept reveal increasing modes with increasing mental age, and (*b*) the data on the sequentiality of development (the re-examination data), while not furnishing absolute proof, do definitely suggest an orderly progression of stages with increasing age.

3. *Although the fundamental validity of Piaget's classification of concept stages has been proven, the data have revealed the impossibility of limiting the age range of the stages as Piaget has attempted to do* This fact is apparent from the complete coverage

of the entire mental and chronological age ranges by each one of the concept stages.

4. *The development of animistic concepts is very nearly the same for all three experimental groups despite their varied geographical locations and socio-economic status.* The three groups—urban, suburban, and rural—were selected because of the belief that the development of animism might be influenced by experience with natural phenomena. In this regard one would expect the suburban children to have more contact with nature than the urban children and the rural children more than either of the other two groups. The facts that there are no *significant* differences in the development of animism between the three groups and that where the differences are great enough to approach significance they favor the urban group as more advanced (*CA* 12°-13" at Stage 3 and Stage 4 levels), indicate that such experience is not an influencing factor.

5. *There are no significant differences in the development of the animistic stages between the male and female subjects in any of the three groups.*

6. *The stages of animism are equally related to both mental age and chronological age, the Coefficients of Mean Square Contingency for the combined groups being 0.59 and 0.62 respectively.*

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AN ADJUSTMENT TEST WITH NORMAL AND HARD OF HEARING CHILDREN*

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Loss of hearing supposedly makes an individual more irritable, less able to understand what is going on around him, perhaps more suspicious, perhaps more obstinate Any or all of this might lead to a less favorable adjustment of the individual to his immediate surroundings. Whether this is true or not, we do not really know. The object of this study is to see whether hard of hearing children in our public schools make less favorable scores on an objective test of adjustment as compared with normal hearing children in the same classes. The study was conducted in the New York City public schools from January, 1934, to the present date The instrument used was the Pupil Portraits Test (1)

A. THE SUBJECTS

The children selected for this study consist of a group of hard of hearing children and a group of normal children, used as a control The hard of hearing children were obtained from a list maintained by the New York League for the Hard of Hearing The selection was based on results of a *2A Audiometer Test* given by the *W P.A* project which carried out the hearing tests in the schools of New York City. Children from the fifth and sixth grades and some from the seventh and eighth grades were chosen

In the selection of subjects only those recently tested for hearing were taken. Those found to be hard of hearing by both the *2A Audiometer* and the otologist were chosen. The average decibel loss in the speech range was used as the measure of hearing loss The

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normal or control group was selected at random from the same classes as the hard of hearing.

The data gathered in this manner have been considered as four samples. *Sample I* consists of a group of normal and hard of hearing children examined before July, 1936. The hard of hearing were taken from 26 schools in Brooklyn, Bronx, Manhattan, and Queens. The total number of children in Sample I is:

	Hard of hearing	*Normal*
Boys	286	295
Girls	324	228

Sample II. The children in this sample were examined from October, 1936, to June, 1937. The hard of hearing were selected from 35 schools in the Bronx, Brooklyn, and Manhattan. The number in this sample is:

	Hard of hearing	Normal
Boys	202	306
Girls	175	274

Sample III: The children in this sample were studied from September, 1937, to June, 1938. The group was selected from 21 schools in the Bronx, Brooklyn, and Manhattan. The total number in this sample is:

	Hard of hearing	*Normal*
Boys	110	115
Girls	69	91

Sample IV. For this sample the same schools were used as for Sample III. However, only seventh and eighth grade children were chosen. These seventh and eighth grade children were selected and chosen in the same manner as the children in the other samples. The total number in this sample is:

	Hard of hearing	Normal
Boys	100	116
Girls	131	179

The total number of cases tested is 3,001, made up of 1,604 normal hearing and 1,397 hard of hearing children.

Each hard of hearing group is divided into two smaller groups according to amount of hearing loss in the better ear. All those children who have a hearing loss of 15 decibels or more in the better ear are put into one group, and all those with a hearing loss of less than 15 are put into another. Each sample therefore, consists of: Normal, Hard of Hearing, Hard of Hearing > 15, Hard of Hearing < 15.

B. The Test

All the children, hard of hearing and normal hearing, were given the *Pupil Portraits Test* This is a group test depending upon oral and printed directions It is a personality test consisting of two parts The first part, called *School Adjustment,* measures the child's adjustment to the school environment The second part, the *Family Adjustment,* measures the child's adjustment to the family situation The test consists of 100 items. Each item describes some situation in the school or the family life of a child For example, Item I reads

S *D* This child tells everybody what a fine school he goes to

The child encircles either *S* for same, or *D* for different, depending on what his reaction to this particular situation is Each item is scored so that the response indicating good adjustment, whether it is *S* or *D*, receives one point The highest possible score is therefore, 100 points A high score indicates good adjustment and a low score poor adjustment The number of items devoted to the school situation is 73. The remaining 27 items deal with the family

C Results on Pupil Portraits Test

We shall present the results for the *Pupil Portraits Test* as a whole and then results of the two sub-tests, the *School Adjustment* and the *Family Adjustment* We shall set forth first the results of the four main samples, three from the fifth and sixth grades and one from the seventh and eighth grades

Table 1 (*a*) shows the results in terms of the *Pupil Portraits* score for each of the samples and for each sex Under each sample we have the four sub-groups, the normal hearing, the hard of hearing < 15, all the hard of hearing, and the hard of hearing > 15 We shall call the hard of hearing with a hearing loss of < 15 decibels, the slightly hard of hearing, and the hard of hearing with a hearing loss of 15 decibels or more, the extreme hard of hearing The slightly hard of hearing plus the extreme hard of hearing constitute the hard of hearing group Table 1 (*a*) presents the *Pupil Portraits* means of each of the control groups so that comparisons may be drawn with the means of the three hard of hearing groups for each sex

TABLE 1 (*a*)

AVERAGE PUPIL PORTRAITS SCORES OF NORMAL AND HARD OF HEARING GROUPS
(5th and 6th Grades and 7th and 8th Grades)

	Sample hearing group	Boys Number	Boys Mean	σ	Girls Number	Girls Mean	σ
I	Normal	295	82.1	11.7	228	86.8	9.1
	Hard of hearing < 15	176	81.5	12.2	156	86.2	10.4
	Hard of hearing	286	79.8	12.8	324	84.3	11.4
	Extreme hard of hearing	110	77.0	13.3	168	82.6	11.9
II	Normal	306	78.7	13.0	274	82.6	11.8
	Hard of hearing < 15	145	76.6	14.4	131	82.5	13.4
	Hard of hearing	202	76.1	14.6	175	81.1	13.6
	Extreme hard of hearing	57	74.9	15.1	44	77.8	13.3
III	Normal	115	77.0	13.5	91	82.0	11.3
	Hard of hearing < 15	40	71.8	15.5	27	84.2	7.3
	Hard of hearing	110	71.6	15.4	69	80.8	10.1
	Extreme hard of hearing	70	71.3	15.2	42	78.6	11.0
IV	Normal	116	77.3	11.5	179	83.4	10.2
	Hard of hearing < 15	54	73.7	13.3	61	85.3	9.1
	Hard of hearing	100	74.8	14.3	131	85.4	8.4
	Extreme hard of hearing	46	76.0	15.3	70	85.6	7.7

TABLE 1 (*b*)

AVERAGE SCHOOL ADJUSTMENT SCORES OF NORMAL AND HARD OF HEARING GROUPS
(5th and 6th Grades and 7th and 8th Grades)

	Sample hearing group	Boys Number	Boys Mean	σ	Girls Number	Girls Mean	σ
I	Normal	295	60.0	8.8	228	63.6	6.5
	Hard of hearing < 15	176	59.8	9.3	156	63.2	7.8
	Hard of hearing	286	58.7	9.7	324	61.9	8.6
	Extreme hard of hearing	110	56.9	10.0	168	60.6	9.2
II	Normal	306	57.7	9.8	274	61.0	8.6
	Hard of hearing < 15	145	55.7	11.2	131	60.5	9.5
	Hard of hearing	202	55.4	11.4	175	59.4	9.9
	Extreme hard of hearing	57	54.7	11.8	44	56.1	10.0
III	Normal	115	57.0	9.9	91	60.4	8.1
	Hard of hearing < 15	70	52.8	11.6	27	61.6	5.4
	Hard of hearing	110	52.6	11.6	69	59.3	7.8
	Extreme hard of hearing	40	52.2	11.6	42	57.8	8.6
IV.	Normal	116	57.0	9.0	179	61.3	7.1
	Hard of hearing < 15	54	54.0	10.2	61	62.7	5.9
	Hard of hearing	100	54.3	10.8	131	62.6	5.7
	Extreme hard of hearing	46	55.8	11.4	70	62.6	5.5

TABLE 1 (*c*)

AVERAGE FAMILY ADJUSTMENT SCORES OF NORMAL AND HARD OF HEARING GROUPS

(5th and 6th Grades and 7th and 8th Grades)

Sample	hearing group	Boys Number	Mean	σ	Girls Number	Mean	σ
I	Normal	295	22.1	3.7	228	23.3	3.3
	Hard of hearing < 15	176	21.8	3.6	156	23.0	3.2
	Hard of hearing	286	21.2	3.8	324	22.4	3.4
	Extreme hard of hearing	110	20.1	3.9	168	21.9	3.5
II	Normal	306	20.8	4.0	274	22.0	3.9
	Hard of hearing < 15	145	20.7	4.0	131	22.2	4.4
	Hard of hearing	202	20.6	4.1	175	21.6	4.4
	Extreme hard of hearing	57	20.3	4.2	44	19.7	3.7
III	Normal	115	20.0	4.6	91	22.2	3.6
	Hard of hearing < 15	70	19.0	4.9	27	22.2	2.7
	Hard of hearing	110	19.1	4.9	69	21.4	3.7
	Extreme hard of hearing	40	19.1	4.8	42	20.9	4.2
IV	Normal	116	21.0	3.8	179	22.1	3.8
	Hard of hearing < 15	54	20.4	4.1	61	22.4	4.0
	Hard of hearing	100	20.2	4.5	131	22.7	3.5
	Extreme hard of hearing	46	20.0	4.9	70	22.9	3.1

The mean *Pupil Portraits* score for each hard of hearing group is below the *Pupil Portraits* mean of the normal group for each sample and for each sex. Also, the general ranking order for the four sub-groups from high to low is (*a*) normal group, (*b*) hard of hearing group < 15, (*c*) all hard of hearing, (*d*) hard of hearing > 15. Although there are some minor deviations from this scheme, this ranking order indicates that the hard of hearing are not so well adjusted as the normal. This ranking order shows also that the greater the hearing loss of the group, the poorer its adjustment. The outstanding exception to this ranking order is Sample IV, Girls. Here the extreme hard of hearing score highest, then the hard of hearing, then the slightly hard of hearing, and then the normal. The girls, whether they are normal or hard of hearing, score higher than the boys when compared group by group. For this reason, the statistical treatment of the boys and the girls has been kept separate, and separate norms for boys and girls have been established.

The *Family Adjustment* and *School Adjustment* tests follow the same trend as the *Pupil Portraits* total as Tables 1 (*b*) and 1 (*c*) show.

In order to view the entire picture presented by all cases considered jointly, the results are combined in Table 2 (*a*). Here the seventh and eighth grade pupils making up Sample IV have been added to the fifth and sixth grade pupils in the other three samples, because the average scores and standard deviations are very similar in all grades concerned. A comparison of the mean *Pupil Portraits* score obtained by all the cases in each hearing group should indicate whether or not there is a difference in adjustment between normal hearing children and hard of hearing children, and to what extent the difference, if any, exists. Table 2 (*a*) sets forth the mean *Pupil*

TABLE 2 (*a*)

PUPIL PORTRAITS SCORE—COMPARISON OF NORMAL AND HARD OF HEARING GROUPS

Hearing groups	Number	Mean	σ	M_{diff}	σ_{diff}	$\frac{M_{diff}}{\sigma_{diff}}$
		Boys				
Normal	832	79.5	12.6			
All hard of hearing	698	76.7	14.3	2.8	70	4.00
Hard of hearing < 15	445	77.4	14.1	2.1	80	2.58
Hard of hearing > 15	253	75.4	15.5	4.1	1.01	4.00
		Girls				
Normal	772	84.0	10.8			
All hard of hearing	699	83.4	11.5	6	58	1.00
Hard of hearing < 15	375	84.6	11.3	7	70	94
Hard of hearing >	324	81.9	11.6	2.0	75	2.69

TABLE 2 (*b*)

SCHOOL ADJUSTMENT SCORES—COMPARISON OF NORMAL AND HARD OF HEARING GROUPS

Hearing groups	Number	Mean	σ	M_{diff}	σ_{diff}	$\frac{M_{diff}}{\sigma_{diff}}$
		Boys				
Normal	832	58.3	9.4			
All hard of hearing	698	56.2	10.9	2.1	53	4.02
Hard of hearing < 15	445	56.6	10.8	1.7	61	2.83
Hard of hearing > 15	253	55.5	11.1	2.8	77	3.66
		Girls				
Normal	772	61.6	7.8			
All hard of hearing	699	61.1	8.5	5	43	1.07
Hard of hearing < 15	375	62.1	8.2	.5	51	93
Hard of hearing > 15	324	60.1	8.8	1.5	.56	2.72

TABLE 2 (c)
FAMILY ADJUSTMENT SCORES—COMPARISON OF NORMAL AND HARD OF HEARING GROUPS

Hearing groups	Number	Mean	σ	M_{diff}	σ_{diff}	$\frac{M_{diff}}{\sigma_{diff}}$
		Boys				
Normal	832	21.1	3.9			
All hard of hearing	698	20.5	4.2	.6	.21	2.93
Hard of hearing < 15	445	20.9	4.1	.3	.24	1.24
Hard of hearing > 15	253	20.0	4.3	1.2	.30	3.89
		Girls				
Normal	772	22.4	3.7			
All hard of hearing	699	22.2	3.8	.2	.19	1.02
Hard of hearing < 15	375	22.6	3.8	.2	.26	.86
Hard of hearing > 15	324	21.7	3.7	.7	.38	2.46

Portraits score for each hearing group for boys and girls separately and compares the averages.

The mean *Pupil Portraits* score for each hard of hearing group of boys is below the mean for the normal hearing. The control group of normal hearing boys has a mean *Pupil Portraits* score of 79.5. This is slightly below the norm established as mean for normal children. The slightly hard of hearing obtain a mean *Pupil Portraits* score of 77.4. Although this is a small difference, it is a statistically significant one. The mean *Pupil Portraits* score for the total group of hard of hearing is lower than that for the slightly hard of hearing. If we now consider the extreme hard of hearing cases, we find their mean of 75.4 drops even below the hard of hearing mean and drops four points below the normal mean. These differences are statistically significant.

To summarize, each hard of hearing group has a mean which is between two and four points below the normal hearing mean. These differences are statistically significant in each case. This is indicated by the fact that the differences between each hard of hearing mean and the normal hearing mean (Mean Difference) are greater than two times the standard error of these differences (σ *Diff.*). This is set forth in Columns 4, 5, and 6 of Table 2. The probability of the mean *Pupil Portraits* score of any hard of hearing group tested being as much as two or four points lower than the normal hearing group is at least 19 out of 20. Hence, the hard of hearing are inferior to the population as a whole in their adjustment. These results are obtained in each of the sub-tests, *Family Adjustment* and *School Adjustment*, for each of the hard of hearing groups of boys with one exception This exception lies in the fact that although the boys with a hearing loss < 15 decibels score differently from the normal boys on the *Family Adjustment* test, this difference is not statistically significant.

Although the difference between the hard of hearing groups of boys and the normal hearing boys is slight, there is even less of a difference between the hard of hearing girls and the normal hearing girls. The differences between the *Pupil Portraits* mean for normal hearing and the hard of hearing group as a whole is less than two. This is also true for the hard of hearing girls < 15 Therefore it cannot be said with certainty that these differences are due to some factor other than chance As a matter of fact, the mean *Pupil Portrait, Family Adjustment,* and *School Adjustment* scores for hard of hearing girls with a hearing loss < 15 is higher than the normal. The hard of hearing girls as a whole are not inferior to the normal population of girls in adjustment. The extreme hard of hearing girls, however, have a mean score which is significantly lower than the normal The facts so far presented indicate that the extreme hard of hearing are not so well adjusted as the normal hearing These results are expressed only in terms of averages for large groups They do not indicate that all extreme hard of hearing children are necessarily maladjusted In fact, many of the extreme hard of hearing children score as high as the best adjusted normal hearing children. This is shown very clearly in Figure 1.

In these graphs, distributions are given for the total normal group and the extreme hard of hearing group As shown in the graphs, the range is the same for all groups and the distributions are very similar. It is seen that the distributions are skewed Most of the cases are at the upper end of the scale.

From the foregoing graphs, it is evident that the distribution of the *Pupil Portraits* test is skewed The median, therefore, may give a better estimate of the central score than the mean. And so, we shall investigate the medians and quartiles of the scores

Table 3 shows the medians and quartiles for the *Pupil Portraits* scores. Once more it is seen that the same trend is followed as in Tables 1 and 2—the greater the loss of hearing, the lower the

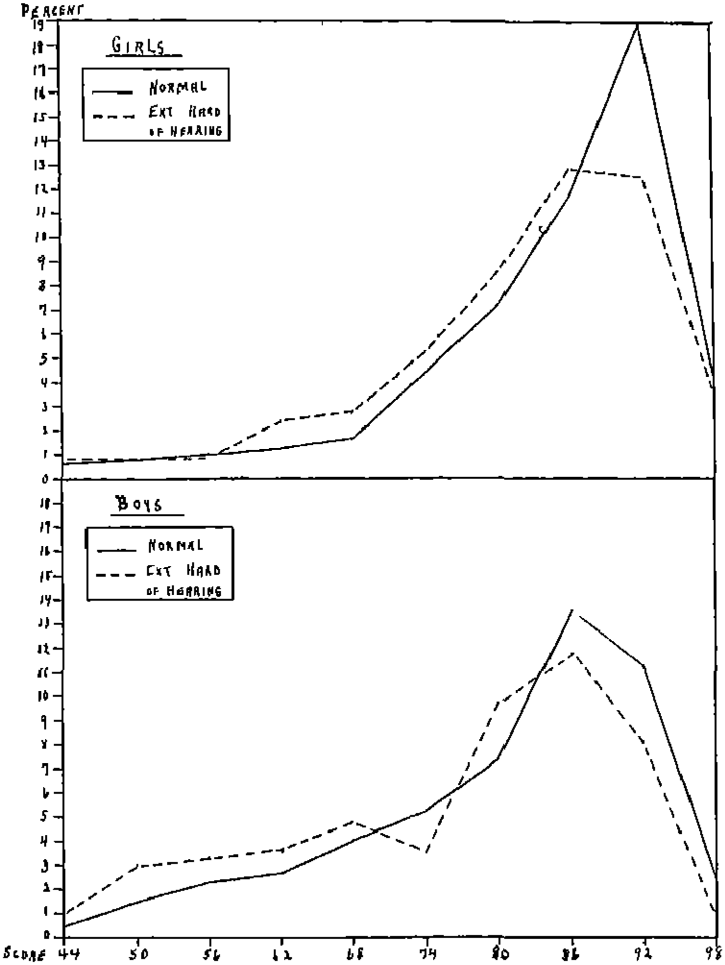

FIGURE 1

Percentage Distribution of Scores on the Pupil Portrait Test

Pupil Portraits score. Here again it can be said that the normal hearing score highest and the extreme hard of hearing score lowest

Since the median for the hard of hearing is lower than the median for the normal, it follows that more than 50 per cent of the hard of

TABLE 3

Medians and Quartiles for Each Group for the Pupil Portraits Scores

	Boys				Girls			
Hearing group	N	Q_1	Md	Q_3	N	Q_1	Md	Q_3
Normal	832	73.1	83.8	89.3	772	79.7	87.4	92.0
Hard of hearing	698	68.5	80.5	86.2	699	79.1	87.1	92.0
Hard of hearing > 15	253	66.2	79.9	84.1	324	77.0	85.5	91.0

TABLE 4

Percentages of Cases Falling Below a Score of 83

Boys

Hearing group	Number	% below 83	$\%_{diff}$	σ_{diff}	$\frac{\%_{diff}}{\sigma_{diff}}$
Normal	832	46.6			
Hard of hearing	698	57.4	10.8	03	4.32
Extreme hard of hearing	253	59.3	12.7	04	3.63

Girls

Percentage of cases falling below a score of 86

Hearing group	Number	% below 86	$\%_{diff}$	σ_{diff}	$\frac{\%_{diff}}{\sigma_{diff}}$
Normal	772	43.7			
Hard of hearing	699	44.3	6	03	23
Extreme hard of hearing	324	51.9	8.2	03	2.49

hearing children will lie below the normal median. Table 4 compares the percentage of cases falling below the class interval in which the median of the normal group fell. Here a larger percentage of cases occurs below this score for the hard of hearing than for the normal. It is also found that a still greater percentage of extreme hard of hearing cases lie below this score. These differences in percentages among the various groups bear out the evidence of the other tables, namely, that the normal are better adjusted than the hard of hearing. These differences between normal and hard of hearing show statistical significance for the boys in both the hard of hearing and extreme hard of hearing groups. For the girls, however, the differences show significance only in the extreme hard of hearing groups.

Another approach to the problem of hearing loss and adjustment can be obtained by considering the correlation of hearing loss with

Pupil Portraits score Tables 5, *a*, *b*, *c*, list the correlations for the hard of hearing samples in relation to better ear and poorer ear.

Most of the correlations are negative They are all small The combined correlations for the total group of 698 boys are not significant. The correlations of 699 girls are slightly significant for both the better and poorer ear. It is interesting to note that in general the correlations between *Pupil Portraits* score and better ear are slightly higher than those between *Pupil Portraits* score and poorer ear

TABLE 5 (*a*)

RELATION OF HEARING LOSS TO PUPIL PORTRAITS

Sample		Number	Correlation with loss on better ear		Correlation with loss on poorer ear	
I	Boys	286	—16		—04	
	Girls	324	—20		—08	
II	Boys	202	—03		03	
	Girls	175	—18		—06	
III.	*Boys*	*110*	—17		—*16*	
	Girls	69	—14		—17	
IV	Boys	100	—06		—00	
	Girls	131	—11		—17	
All boys		698	—06	*SD*, 04	—03	*SD*, 04
All girls		699	—13	*SD*, 04	—12	*SD*, 04

TABLE 5 (*b*)

RELATION OF HEARING LOSS TO SCHOOL ADJUSTMENT

Sample		Number	Correlation with loss on better ear		Correlation with loss on poorer ear	
I	Boys	286	—15		—02	
	Girls	324	—19		—.07	
II	Boys	202	—03		01	
	Girls	175	—18		—.06	
III	*Boys*	*110*	—23		—12	
	Girls	69	—15		—20	
IV	Boys	100	—.06		—03	
	Girls	131	—14		—19	
All boys		698	—08	*SD* 04	—01	*SD* 04
All girls		699	—13	*SD* 04	—15	*SD* 04

TABLE 5 (*c*)
RELATION OF HEARING LOSS TO FAMILY ADJUSTMENT

Sample		Number	Correlation with loss on better ear		Correlation with loss on poorer ear	
I	Boys	286	—.16		—.07	
	Girls	324	—.20		—.10	
II.	Boys	202	—.03		.08	
	Girls	175	—.16		—.04	
III	Boys	110	.02		—.20	
	Girls	69	—.06		.04	
IV.	Boys	100	—.06		.08	
	Girls	131	—.05		—.11	
All boys		698	—.07	*SD* .04	—.01	*SD* .04
All girls		699	—.11	*SD* .04	—.04	*SD* .04

D. RESULTS OF PARTIAL AND MULTIPLE CORRELATION

In order to make a study of the partial and multiple correlations between *Pupil Portraits* score, hearing loss, and intelligence, those hard of hearing cases were selected from the four samples which had both *Pupil Portraits* scores and *P.I.T.* scores. The *P.I.T.*, *Pintner Intelligence Test*, is a group intelligence test of the usual type, being predominantly verbal and depending on oral and printed directions.

There were 585 boys and 624 girls, 1,209 cases in all which had these two scores. The correlations between *Pupil Portraits* score and hearing loss, between *Pupil Portraits* score and Mental Age as determined from the Pintner *Intelligence Test*, and between Mental Age and hearing loss were called r_{12}, r_{13}, r_{23}, respectively. Then the partial correlation coefficients $r_{12.3}$, between *Pupil Portraits* score and Hearing Loss with Mental Age eliminated, and $r_{13.2}$, between *Pupil Portraits* and Mental Age with Hearing Loss eliminated, were computed. This was done separately for boys and girls. The results are set forth in Table 6. The correlation of *Pupil Portraits* score with Hearing Loss (r_{12}) is —.03 for the boys. This figure is not significant. The correlation of *Pupil Portraits* score with Mental Age is +.30. The partial coefficient of correlation ($r_{12.3}$) between *Pupil Portraits* score and Hearing Loss with Mental Age eliminated, is increased from —.03 to —.07. But —.07 is only 1.6 times its standard error. Therefore —.07 cannot be considered statistically significant.

TABLE 6

PARTIAL CORRELATIONS FOR PUPIL PORTRAITS, HEARING LOSS, AND MENTAL AGE

	r	SD	
		Boys—585 cases	
r_{12}	—03	04	not significant
r_{13}	30	04	significant
r_{23}	10	04	significant
$r_{12.3}$	—07	04	not significant
$r_{13.2}$	31	04	significant
		Girls—624 cases	
r_{12}	—12	04	significant
r_{13}	42	03	significant
r_{23}	—07	04	not significant
$r_{12.3}$	—11	04	significant
$r_{13.2}$	42	03	significant
		Boys and girls combined—1,209 cases	
r_{12}	—04	03	not significant
r_{13}	35	03	significant
r_{23}	00	03	not significant
$r_{12.3}$	—.05	03	not significant
$r_{13.2}$	35	03	significant

The correlation between *Pupil Portraits* score and Mental Age does not alter much when Hearing Loss is eliminated The coefficient changes from 30 to a partial correlation coefficient of 31. A study of the partial correlation for girls, and for boys and girls combined leads to the same conclusions

Since intelligence scores and hearing loss records were available, it was interesting to find the relationship between the *Pupil Portraits* score on the one hand, and Hearing Loss and Mental Age on the other. This problem leads to the evaluation of the multiple correlation between *Pupil Portraits* score as the dependent variate, and the measures of Intelligence and Hearing Loss as independent variates For this purpose, the same correlations used in the work with partial correlations were employed These correlations for the boys are

Pupil Portraits score and Hearing Loss in Better Ear	—03
Pupil Portraits and Mental Age	.30
Hearing Loss and Mental Age	.10

The multiple correlation then obtained is:

$R = 31$

This value is very nearly the same as those obtained from the correlation of *Pupil Portraits* score and Mental Age, and of *Pupil Portraits* score and Mental Age with Hearing Loss eliminated, namely, .30 and .31.

The multiple correlation coefficient for girls is .42, which is the same as the partial correlation between *Pupil Portraits* score and Mental Age. When boys and girls are combined, the multiple correlation coefficient is .35. The partial correlation coefficient of Mental Age is also 35.

E SUMMARY

This study raises the question as to the general adjustment of hard of hearing public school children. The test used was the *Pupil Portraits Test*, which was given to 3,001 children in Grades 5 to 8. There were 1,604 normal hearing and 1,397 hard of hearing cases. The hard of hearing cases had been tested for hearing by the 4*A* audiometer, the 2*A* audiometer, and by otologists Hearing loss in the better ear as measured by the 2*A* audiometer was the quantitative measure used

The mean score for the normal group of boys is 79.5, for the hard of hearing boys 76 7. This difference is statistically significant The mean score for the extreme hard of hearing is 75 4 which is lower than the mean of the hard of hearing in general The difference between this score and the normal scores is also statistically significant The normal girls have a mean score of 84.0, and the hard of hearing girls have a mean score of 83.4. This difference is not significant. The extreme hard of hearing girls with a mean score of 81.9 show a significant difference from the normal. In all cases, it will be noticed that the girls do better than the boys.

In general the hard of hearing seem to be slightly less well adjusted as measured by our test. This difference is not great for the boys and disappears entirely so far as the girls are concerned It is only when we take the extreme hard of hearing groups, i.e., those with a hearing loss greater than 15 decibels, that we find a definite drop in score for both boys and girls. Evidently these extreme hard of hearing children feel that they are less well adjusted than normal hearing children. Although the mean differences between the extreme hard of hearing groups and the hearing control groups are statistically significant, the actual differences in score are not great. They are not great enough to conclude that a certain degree of auditory deficiency generally brings about lack of adjustment in school. The positive aspect of this study needs to be emphasized, namely, that most hard of hearing children in school vary as to their feelings of adjustment pretty much in the same way as their normal hearing classmates. Auditory deficiency is a real handicap, but in most cases the hard of hearing child seems to make a normal adjustment so far as we can measure this by our test. As the auditory deficiency becomes more severe he seems to feel less well adjusted. It may be that we might help to wipe out this difference by a recognition of his auditory defect early in his school career, so that suitable means for aiding him could be promptly initiated.

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The Journal of Genetic Psychology, 1940, 56, 383-409

A NEW PICTURE COMPLETION TEST*

Judge Baker Guidance Center

LOUISE WOOD[1]

A INTRODUCTION

Probably no performance test has been more widely used or has aroused more interest than Healy's *Pictorial Completion Test II* Wells (20) considers it "among the major psychometric achievements" Besides very extensive use in the United States, child guidance clinics in many European countries, as well as in Australia and Canada, have found it a valuable part of testing equipment While there is little systematic data relating to its practical application, it has been considered a test of special apperceptive ability by numerous authors. It has been found useful in work with mental defectives and illiterates, and has been especially advocated for the examination of delinquents and individuals showing poor social adjustment.

The completion test appeared early in the development of test techniques and has continued much in favor. Ebbinghaus and later Trabue developed language completion tests, while Heilbronner had originated a series of incomplete pictures as early as 1905 Healy was the first to apply the concept to a performance test in his *Pictorial Completion Test I* which appeared in 1914 His second test was a further elaboration of the idea with a far greater range of difficulty in the separate problems and a continuity of narrative lacking in the first. Soon after the publication of the Healy *Test II* in 1917 it was requested for use by the War Department and was incorporated in the Army performance scale for the individual examination of

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illiterates and non-English speaking subjects. Later it has appeared in several other performance scales, notably the second form of the Arthur (1) *Point Performance Scale*, the Gaw (3) *Performance Tests of Intelligence*, and as an alternate in the Cornell-Coxe (4) *Performance Ability Scale*.

Various completion tests have been developed since the appearance of the Healy test In 1918 Shaw (17) published a picture test and in the same year Pintner and Toops (15) brought out a drawing completion test for young children. Street (18) devised the *Gestalt Completion Test* which appeared in 1931 However, a need has been felt by many in the clinical field for a test which more closely corresponds to *Healy II*. There has been nothing available which could be utilized for checking the performance on the Healy test Even retesting after an appreciable interval has proved unsatisfactory because of the great practice factor involved The Wood *Picture Completion Test* has been developed as a companion piece to the Healy *Pictorial Completion Test II* in an effort to fill this need

B. Development of the Test

In devising a substitute for the Healy test, the form of the test, the size, number and arrangement of the pictures, and as far as possible the coloring were purposely imitated. Like the original, the Wood test consists of 11 pictures, one at the left to be used for demonstration, and the other 10 in two rows of five each, mounted on two boards of three-ply wood. Each picture has an inch-square cut out, and accompanying the boards are 60 inch-square pieces. The pictures show a succession of activities illustrating a school girl's day, a girl being chosen as the central figure, in contrast to Healy's boy, in order to make it possible to vary the individual test problems more easily. The difficulties involved in devising test pictures where the missing objects must be depicted on inch-square blocks with a uniform background color are very great and the possibilities definitely limited. There is no actual duplication of Healy's problems although there are some slight similarities between the two series Care was taken to have the situations in the new test involve something thoroughly familiar to both boys and girls as well as to children in any walk of life

As in the Healy test, there is one correct solution for each of the test situations and also for each there are one or more planned alternates to the correct solution. These will be designated in this article as *"correct"* and *"alternates"* respectively, all other possibilities being classed as *"errors."* For convenience, the 10 test pictures will be referred to by numbers, using Roman numerals, and the 60 pieces, which are numbered according to their standard arrangement in the box, by Arabic numerals.

From many possible suggestions for test situations 11 were chosen as the most workable, and sketches were made by a competent artist. The accompanying small pieces included the correct solutions, the planned alternates and a collection of extra pieces intended as errors, a few of the latter being blanks. In general, there are two types of alternates, one which gives a variation of the correct solution and one which shows an entirely different but plausible object. In two instances there is a combination of the two types.

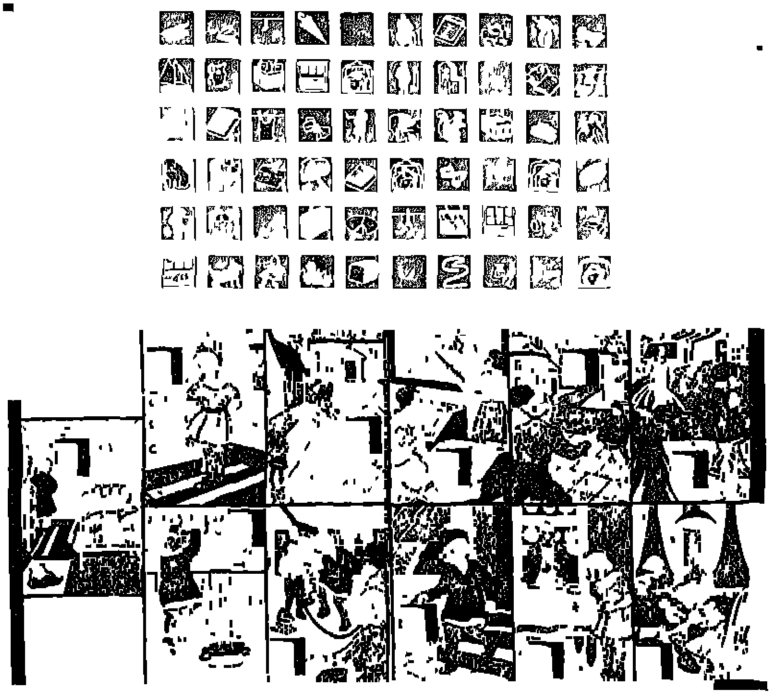

FIGURE 1

After using this trial set for several months at the Judge Baker Clinic one of the original pictures was found to be impractical and was replaced, and many changes were made in the others as well as the insets. The resulting series was also used for a number of months until no new discrepancies in the details or difficulties with size or perspective were observed. A third set of pictures was drawn and from this edition of the test about 250 records were collected, again at the Judge Baker Clinic. Upon analysis these showed that not only the total number of correct solutions increased quite definitely and fairly regularly with chronological age, but the correct solutions for the separate subtests also showed a fairly consistent age trend. This was also true for the sum of correct and alternates. It was at this point that the test was put into final printed form so that data for standardization could be gathered (Figure 1).

C. DIRECTIONS FOR ADMINISTERING

The two boards are placed close together directly in front of the subject with the box containing the pieces at one side, preferably at the right. The examiner says:

> These pictures tell the story of a girl's day. They show the same girl doing one thing after another on the same day. They begin here, where she's getting up in the morning, and take her right through the day (*Indicate sequence of pictures by pointing.*) You see that there is a piece missing from each picture These pieces fit any of the spaces, but there are too many to go in at once You are to pick out the one for each space that completes (finishes) the sense of the picture. Let's start here (*Demonstration picture*)

If the child selects the correct piece for the demonstration picture, the window with the sun (No. 51), the alternate showing the moon (No 48), is shown to him with the query, *"Would this window do as well?"* There is rarely any confusion on this point although occasionally, with younger children, it is necessary to reiterate the fact that the girl must be getting up since the picture begins the series. The second alternate, showing rain (No. 14), is then indicated with the same form of question, *"Would this window do as well?"* If the child gives any correct reason based on the other pictures in the set it is accepted, but he is urged to find a clue in the demonstration picture itself and if necessary the cat's shadow is pointed out to him.

If the subject fails to select the correct piece for the demonstration picture he is asked to find something better, and may be helped by questioning and suggestion to find the right solution. The procedure described above, of indicating the alternates, then follows. It is of the utmost importance that the subject understands before starting the actual test that there is continuity in the series and that there is only one correct solution for each situation. No further help is given unless the child asks whether he may make changes, which he is allowed to do.

There is no definite time limit on the test, and the time element does not enter into the scoring. No mention is made of time unless the subject inquires about it, in which case he is assured that he need not feel hurried. The child who performs the task hastily and carelessly should be urged to look over his work and make sure that he has done his best. If at the end of 20 minutes the test is not practically finished it may be removed and scored as a failure. This provision is to take care of the occasional subject who finds it impossible to make decisions, usually a younger child who has failed to grasp the problem adequately. For subjects 12 years and up the average time needed for completing the test is about 10 minutes, with comparatively little variation by age. Below the 12-year level the average time increases gradually, in inverse ratio to age, to approximately 15 minutes at the eight-year level.

At the completion of the test all the correct placements are questioned by indicating the planned alternates for each as given in the key below with the query, *"Would this one, or this, or this have done as well as the one you have put in?"*

There is a slight variation in this procedure (Table 1) for Pic-

TABLE 1

Picture	Correct placements	Alternates
I	39	15, 36, 60
II	25	16, 41
III	19	7, 22, 35
IV	54	6, 21
V	2	59
VI	46	20, 23, 42, 3
VII	37	10, 24
VIII	13	47, 28, 32
IX	8	45, 49
X	50	1, 58

tures VI and VIII In Picture VI the first three alternates, Nos 20, 23, and 42 are shown, and if one of them is accepted, alternate No 3 is not mentioned If, however, the child responds that there should be another stocking on the line, the fourth alternate, No. 3, is indicated. In Picture VIII the alternates are given singly, first No. 47, the school bag, to see if the child has grasped the general situation, then No 28, the empty basket, and lastly No 32. With older children No 47 may be omitted as too obvious

In any case where the subject accepts an inferior choice, credit is given for the final selection rather than for the correct solution. Very occasionally a child will insist on retaining the correct piece without being able to give an adequate reason, but it seems obvious that unless he is able to verbalize his reasoning it cannot be sufficiently clear to deserve full credit. Those who have used Healy's test to any extent are familiar with the frequency with which correct placements are made by chance. Healy's directions call for questioning in all cases where the correct solution is suspected of being accidental, but many users have adopted a more systematic method. This procedure has been continued in the new test.

D Selection of Group

The test was administered to 1,026 public school children, ranging in age from 7 years 6 months to 17 years 5 months and in grade from second to twelfth, approximately the same number of boys as girls The nine schools used included four grade schools, two junior high schools, and three senior high schools, located in three large suburban districts with heterogeneous populations including a fair sprinkling of Negroes and Italians The testing covered a period of eight months in the school year of 1935-36, care being exercised to take samples from the different grades before and after the middle of the year There was no reference to school marks or class standing However, children more than two years retarded in grade for age were excluded, as well as those considered by the teacher as definitely mentally retarded, and in instances where an intelligence rating was available, those with an *IQ* below 80. In the junior high school and high school groups the various courses, college, general, and commercial, were about equally represented. The selection throughout was made first by grade, but because of the immense amount of time needed for the giving of this test individually to such numbers, the age-level groups were kept at approximately 100 each. Table 2 gives the distribution of the total group by age and sex and Table 3 by age and grade.

TABLE 2
DISTRIBUTION BY AGE

Age	Boys	Girls	Total
7/6- 8/5	50	50	100
8/6- 9/5	51	51	102
9/6-10/5	51	54	105
10/6-11/5	53	50	103
11/6-12/5	52	50	102
12/6-13/5	53	51	104
13/6-14/5	53	52	105
14/6-15/5	51	52	103
15/6-16/5	50	51	101
16/6-17/5	51	50	101
	515	511	1,026

TABLE 3
DISTRIBUTION BY AGE AND GRADE

	Age									
Grade	8	9	10	11	12	13	14	15	16	17
2	24	5								
3	73	36	6							
4	3	58	34	9						
5		3	63	33	6					
6			2	60	41	8				
7				1	55	45	7			
8						51	44	4		
9							54	45	6	
10								53	57	6
11								1	38	52
12										43
Totals	100	102	105	103	102	104	105	103	101	101

E Development of Scoring Scheme

Some statistical analysis of the raw data was necessary before it was possible to determine what sort of scoring scheme should be adopted It was essential to know the logical stipulations inherent in the test construction and the consequent treatment the data required. The first problem which presented itself was whether the test should be scored for each age separately, whether it needed standardization for one marked age level only, or whether the scoring should be based on some generalized age factor. The first step was to ascertain whether or not the correct responses showed the same relative difficulty for all age levels The possibility that a certain test situation might be easier for a young child than for an adolescent is quite conceivable, as the more mature intelligence might be an actual handicap in solving a relatively simple problem. Should this assumption have proved true it would have been necessary to construct a score for each age separately. By arranging the frequencies of correct answers for each subtest by age we find that only the absolute frequencies differ from age to age, but that for each age the number of correct responses is distributed over the 10 tests in proportion to the total correct placements for each age. X^2, the measure of discrepancy between observation and expectation, is entirely insignificant and consequently we may conclude that it is unnecessary to score the test for each age separately.

Some age differentiation in the use of the alternates could justify the use of a general age factor However, when an analysis of the frequencies of these was made, it appeared that while the differences in correct responses were balanced by differences in errors, the alternates were used, with a few exceptions, by all ages with the same absolute frequencies. Table 4, giving an analysis of the responses to Picture I illustrates the method used which, of course, was applied to the other nine subtests in the same manner.

It should be noted that the significant contributions toward the X^2 of 202 came entirely from the "correct" placements and from "other errors" but that the use of the various "alternates" and of the "blanks" is not differentiated by age as evidenced in the insignificant X^2's of these columns.

In the light of these findings it was entirely justifiable to standardize the test for one age only, the question being which age to select. As may be seen from Table 4 the 12-year level had the lowest X^2 value for Picture I and this held true for the rest with the exception of Picture III and with the above exception the value of X^2 was always insignificant for the 12-year level. Consequently the 12-year level was used as the standard level.

There are some other features of this analysis which should be noted before passing on to the development of the scoring method.

Subtest I

Age in years	Correct No 39		Alt No 15		Alt No 36		Alt No 60		Blanks		Other errors		Totals	
8	15 61	2	03	22	77	23	66	26	3 11	4	44 27	23	64 45	100
9	12 61	4	12	25	1 69	35	74	24	.99	3	3.31	11	19 46	102
10	5 30	10	.35	21	31	32	02	24	.05	2	12 91	16	18 94	105
11	80	16	3 84	33	01	28	2 08	16	6 41	5	56	5	13 70	103
12	73	16	95	28	13	30	02	22	05	2	90	4	2 78	102
13	1 67	26	1 19	29	98	34	5 33	12	29	1	3 21	2	7 87	104
14	3 63	29	1 00	19	86	24	2 54	31	1 70	0	5 30	2	13 03	105
15	9 80	34	2 39	16	.20	26	42	26	1 70	0	4 65	1	19 16	103
16	5 00	30	1 57	29	1 25	22	52	19	1 70	0	4 17	1	14 21	101
17	8 89	32	5 33	12	05	29	1 34	28	1 70	0	6 90	0	24 21	101
Totals	64 04	199	16 77	234	6 25	283	13 67	228	17 70	17	84 18	65	197 81	1026

The large numbers are the frequencies The small numbers are $\frac{(\textit{observed frequency-expected frequency})^2}{\textit{expected frequency}}$

$X^2 = 202$

There is some association between the number of the alternates available for a test situation and the frequency of errors. In general, where there are many alternate pieces few errors are made, and the converse is true where there are few alternates Except for Pictures V and VII errors are not particularly frequent Picture V is the only instance in which there is a single alternate. In the case of Picture VII, while two alternates are provided, the problem is such that with few exceptions it is grasped in entirety or not at all

Having found a basis of selection of the standard level, it remained to decide on the type of scoring method. Obviously, it must fulfil certain conditions In the first place it was noted that while the frequencies of the correct placements reflected the degree of difficulty of the individual test situations, this was not necessarily true of the alternates and errors. Consequently the scoring system must be of a heterocritical nature, with the correct solutions evaluated in relation to each other, while the alternates and errors must not be related to each other but to the frequency of correct placement of the given subtest Furthermore, it is evident that the alternates for certain subtests are more difficult than the correct placements on some other subtests and, again, that some types of errors may have greater merit than some alternates. Alternates may have a small frequency because the correct solution is easy or because both the correct and the alternate placements are difficult. The scoring plan must do justice to all these conditions.

It was clear that there is no well-rounded statistical scoring system which would fulfil all these requirements. Instead, it was necessary to develop a semi-arbitrary system, reached through a succession of steps based on statistical procedures. The first step was to obtain a first approximation to the values of the correct placements by taking the reciprocals of their frequencies (based on the frequencies of the 12-year level) and expressing them as percentages of the sum of the reciprocals. Correcting to the next integer we have the figures as given in Table 5

Since the frequencies of Subtests I, VII, and VIII differed from each other by chance only, it did not seem justifiable to assign different values to them. Accordingly a value of 17, or the average of the three scores was assigned to each one However, while these three subtests did not differ from each other in difficulty from the standpoint of frequency of correct solution, there were actually

TABLE 5

Subtest	Value of correct placement
I	19 (17)
II	9
III	3
IV	5
V	14
VI	7
VII	18 (17)
VIII	16 (17)
IX	5
X	6

differences in degree of difficulty as reflected in the number of errors The next step then was to correct the 10 values by a correction figure derived through multiplying the number of errors of a given subtest by the reciprocal of the correct frequency and dividing by 10 This figure was added (integers only) to the above scores, thus giving values for the correct placements in which both absolute and relative difficulty were reflected, though the latter is given a slight weight only This adjustment gave the values, still only temporary, listed in Table 6

TABLE 6

Subtest	Value of correct placement
I	18
II	10
III	3
IV	5
V	17
VI	7
VII	21
VIII	17
IX	5
X	7

The next procedure was the scoring of errors. The following formula was used to obtain the merit of error placements

$$10\,X\left(\frac{\textit{no correct placements and alternates} - \textit{no errors}}{\textit{no correct placements and alternates} + \textit{no errors}}\right)$$

Thus negative weights were obtained when errors were in defect of correct and alternate placements and positive weights if they were in excess, the weights varying from —10 to +10 These weights, adjusted to the next integer, appear in Table 7 The zero

TABLE 7

Subtest	Weight of errors
I	—9
II	—6
III	—10
IV	—4
V	+4
VI	—10
VII	+6
VIII	—10
IX	—9
X	—6

point was assumed to be —10, and all other scores were shifted upwards accordingly.

There now remained the assignment of values for the alternates.

TABLE 8

SCORING TABLE

	Correct	Alternates				Errors
I	(39) 28	(15) 5	(36) 5	(60) 5		(18, 12, 17, 47, 48) 1 all other errors, 0
II	(25) 20	(16) 4	(41) 8			(18) 3 (9, 26, 27, 30, 31, 62) 1 all other errors: 0
III	(19) 13	(22) 6	(35) 0	(7) 0		All errors: 0
IV	(51) 15	(6) 0	(21) 10			(10) 2 (17) 4 all other errors 0
V	(2) 27	(59) 20				(18) 6 (52) 8 all other errors 0
VI	(16) 17	(3) 4	(20) 1	(23) 2	(42) 2	All errors: 0
VII	(37) 31	(10) 23	(21) 0			(18) 2 (57) 8 (40) 2 (30, 52, 53) 1 all other errors 0
VIII	(13) 27	(20) 1	(32) 7	(14) 0	(47) 1	All errors 0
IX	(8) 15	(45) 7	(49) 1	(53) 0		All errors: 0
X	(50) 17	(1) 9	(58) 1			(18, 19, 22, 29, 30, 31, 33, 35, 44, 52, 53) 1 all other errors, 0
	210					

The large figures are the scoring values, the small figures in parentheses are the numbers of the blocks to which the scores refer. Where 18 is given a value, a corresponding value is given to any of the other blanks, 5, 38, 43, 56.

This was done by adding the score of total errors to the score of corresponding correct, and taking the average. This placed the alternates half way between the values of the correct and the errors for any given picture, but through indirect influence of the correct it also placed the alternates in relation to each other. The complete scoring, giving the final values for the correct placements as well as the values for alternates and errors appears in Table 8.

It will be seen that the stipulations for the scoring system set forth earlier in this article are fulfilled by the above plan. The values for the correct solutions are related to each other in degree of difficulty of their respective test situations. The alternates are related directly to the frequency of the correct placements and indirectly to each other. In some instances alternates have a higher score than the correct solution for other pictures. (For example Alternate 10 of Subtest VII has a higher value than the correct of Pictures III, IV, VI, IX, and X.) Certain errors have higher values than the alternates for other pictures. (Error No. 52 of Subtest V scores higher than a number of the alternates for other subtests.) It will be noted that Healy's system of penalizing all irrational placements by assigning a value of —5 to them has not been followed in the scoring of this test.

F. Results

The scores for each of the 1,026 subjects were computed by the scoring table and frequency distributions made for each age-level for

TABLE 9

Age	N	Boys Mean	SD	N	Girls Mean	SD
7/6- 8/5	50	45.44	16.89	50	48.18	22.99
8/6- 9/5	51	58.92	25.62	51	60.51	30.26
9/6-10/5	51	72.12	32.55	54	69.98	29.76
10/6-11/5	53	88.79	33.15	50	92.28	34.41
11/6-12/5	52	103.88	31.49	50	104.98	29.69
12/6-13/5	53	108.81	32.76	51	110.81	32.49
13/6-14/5	53	122.47	34.15	52	123.69	37.05
14/6-15/5	51	135.35	33.28	52	119.19	28.91
15/6-16/5	50	128.36	34.52	51	134.14	35.38
16/6-17/5	51	128.16	23.81	50	135.48	31.91
	515			511		

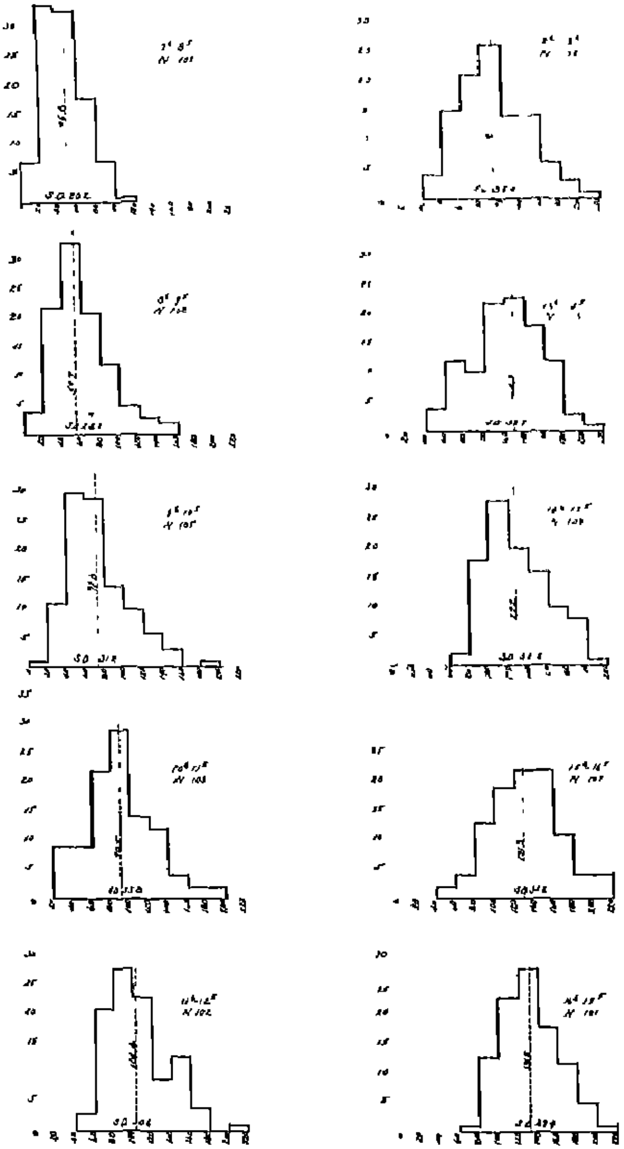

FIGURE 2

boys and girls separately. The means and standard deviations for these groups are given in Table 9.

Except for age level 15, where the mean for boys is significantly higher than for girls, the means and standard deviations do not *differ significantly*. The single exception of the 15-year level naturally does not invalidate the merging of boys and girls into one group for each age level. Graphs of the frequency distributions for these merged groups show in Figure 2, and Table 10 gives the means and standard deviations of these frequencies.

TABLE 10

MEANS AND STANDARD DEVIATIONS OF AGE GROUPS

Age	*N*	Mean	*SD*
7/6- 8/5	100	46.8	20.2
8/6- 9/5	102	59.7	28.1
9/6-10/5	105	71.0	31.2
10/6-11/5	103	90.5	38.8
11/6-12/5	102	104.4	30.6
12/6-13/5	104	111.9	33.4
13/6-14/5	105	124.3	33.7
14/6-15/5	103	127.2	32.2
15/6-16/5	101	131.3	34.2
16/6-17/5	101	131.8	28.4

It is gratifying that the results show no sex difference which would have necessitated a double standard of norms. Gaw (9) found no sex difference in her work with the Healy test. Vernon (19) found a slight difference in favor of males, but it was not statistically significant. A significant sex difference on the Wood test would have militated against its usage as a substitute for the Healy test, as well as limiting its general usefulness.

For practical use deciles are undoubtedly the most satisfactory type of norm. These have been computed for each age group and have been slightly smoothed. Table 11 gives these results.

It was evident from the means of the age arrays that the relation between scores and *CA* was not linear. Consequently a correlation ratio, rather than a correlation coefficient was computed for the 1,026 subjects with a resulting η of .689. This is a fair degree of relationship but not sufficient for the prediction of an individual performance. On the other hand the mean of a group can be predicted very satisfactorily from such a relation.

TABLE 11

	Deciles									
Age group	1	2	3	4	5	6	7	8	9	10
7/6- 8/5	23	30	36	40	46	52	58	66	78	120
8/6 9/5	30	37	44	50	56	63	71	82	101	160
9/6-10/5	38	48	54	60	66	74	82	98	120	200
10/6-11/5	45	64	74	81	87	94	104	119	135	200
11/6-12/5	69	77	85	91	100	108	117	129	146	210
12/6-13/5	70	83	93	101	108	116	129	144	159	210
13/6-14/5	72	89	104	114	124	132	143	154	167	210
14/6-15/5	92	101	108	116	124	134	146	158	176	210
15/6-16/5	92	101	112	122	132	140	148	158	176	210
16/6-17/5	96	106	115	123	132	140	148	158	176	210

(Slightly smoothed)

N, of course, gives only the degree of relation but nothing of its character. The nature of the scatter suggested that the relation between score and chronological age was of some logarithmic nature, though not a simple logarithmic curve. At the same time it was evident that for the observed range some kind of a parabola would fit the data perfectly well. Because we were interested in predicting standards for the observed range but not in describing the law of a curve, it seemed justifiable to use the parabola, especially since it is much easier to fit than the logarithmic curve and since it is much simpler to test the goodness of fit (Figure 3).

The equation of the simple parabola obtained here is: $Y = 171.03 + 34.64x - 0.98x^2$ where Y is the predicted score and x is the chronological age. *The η obtained* was .69. The goodness of fit was tested by an analysis of variance. According to this analysis deviations from the straight line were significant, but *deviations from the simple parabola* were not significant.

In Table 12 are given the predicted scores for each year and month within the observed range. Mental ages can be obtained from this, but, as shown by Figure 3, the scatter around each predicted score is very great and consequently the deciles for each age are more relevant norms. On the other hand, the expression of the results of the *Picture Completion Test* in terms of mental age might be justified by the fact that the scatter is no greater than that found for some of the widely used tests from which an *IQ* is derived.

Records of test results on the Kuhlmann-Anderson *Scale* were available at the various schools on 403 of our subjects, all 8th

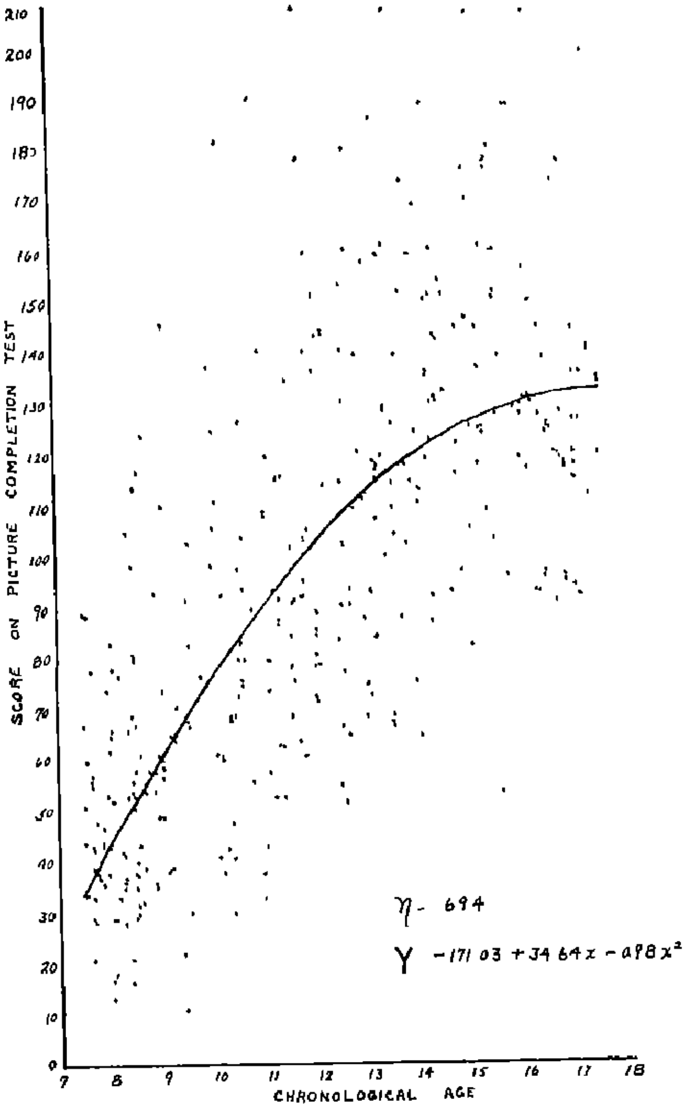
SCORE ON PICTURE COMPLETION TEST
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
7
8
9
10
11
12
13
14
15
16
17
18
CHRONOLOGICAL AGE
η - 694
Y $-171\ 03 + 34\ 64x - .98x^2$

FIGURE 3

TABLE 12

Chronological age Year	Month	Predicted score
7	6	33.6
	7	35.2
	8	37.0
	9	38.6
	10	40.1
	11	41.8
8	0	43.4
	1	44.9
	2	46.6
	3	48.0
	4	49.5
	5	51.2
	6	52.6
	7	54.0
	8	55.6
	9	57.0
	10	58.4
	11	60.0
9	0	61.4
	1	62.7
	2	64.2
	3	65.5
	4	66.9
	5	68.3
	6	69.6
	7	70.9
	8	72.3
	9	73.5
	10	74.8
	11	76.2
10	0	77.4
	1	78.6
	2	79.9
	3	81.1
	4	82.8
	5	83.5
	6	84.6
	7	85.8
	8	87.0
	9	88.1
	10	89.2
	11	90.4

TABLE 12 (*continued*)

Chronological age Year	 Month	Predicted score
11	0	91.4
	1	92.5
	2	93.6
	3	94.6
	4	95.6
	5	96.8
	6	97.7
	7	98.7
	8	99.8
	9	100.7
	10	101.3
	11	102.6
12	0	103.5
	1	104.4
	2	105.4
	3	106.2
	4	107.1
	5	108.0
	6	108.8
	7	109.6
	8	110.8
	9	111.3
	10	112.1
	11	112.9
13	0	113.7
	1	114.4
	2	115.2
	3	115.9
	4	116.6
	5	117.3
	6	118.0
	7	118.7
	8	119.4
	9	120.0
	10	120.6
	11	121.3
14	0	121.9
	1	122.4
	2	123.0
	3	123.6
	4	124.1
	5	124.7
	6	125.2
	7	125.7
	8	126.2
	9	126.7
	10	127.2
	11	127.6

TABLE 12 (*continued*)

Chronological age Year	Month	Predicted score
15	0	128.1
	1	128.5
	2	128.9
	3	129.3
	4	129.7
	5	130.1
	6	130.4
	7	130.8
	8	131.1
	9	131.4
	10	131.7
	11	132.1
16	0	132.3
	1	132.6
	2	132.9
	3	133.1
	4	133.3
	5	133.5
	6	133.7
	7	133.9
	8	134.1
	9	134.2
	10	134.4
	11	134.5
17	0	134.6
	1	134.7
	2	134.8
	3	134.9
	4	135.0
	5	135.0
	6	135.0
	7	
	8	
	9	
	10	
	11	

grade or below. Only ratings which had been obtained within a year of the time of administering the picture completion test were included, and the large majority had been secured within six months of that time. An estimated mental age was computed from the Kuhlmann-Anderson *IQ*, and the chronological age at the time the completion test was given. When these mental ages were plotted against the completion test scores, a curvilinear relationship was evident, and consequently a correlation ratio was computed For the 403 cases this figure was 59, showing a fair degree of correspondence between mental age and completion test performance.

In spite of the widespread use of the Healy *Completion Test*, there seems to be surprisingly little available data on its correlation with other tests. Such figures as can be found show considerable variation, having been worked out on groups selected on varying bases and frequently with insufficient numbers Much of the work has been done with delinquents In a study of a large number of repeated offenders Bronner (3) correlated completion tests scores with Stanford-Binet *IQ* by the rank difference method for ages 11, 12, 16, and 17 separately, the *r*'s ranging from 0 to 33. Worthington (21) found an *r* of 41 between completion score and Stanford-Binet mental age on 143 unselected cases at the Chicago Bureau of Juvenile Research. Shakow and Millard (16), in a study of 150 adult delinquents, found an *r* of .40 with the Stanford-Binet Vernon (19), at the Maudsley Hospital in London, compared completion scores for 79 subjects 15 years and over with the Stanford-Binet with a resulting figure of 54 Morganthau (13) also found an *r* of .54 between the same measures on 116 unselected children in the 6th, 7th, 8th, and 9th grades. The figure found in the army testing was higher, 65, based on a group of illiterate and non-English speaking men It has been generally conceded that the Healy test does not have a high correlation with the Stanford-Binet, although few of the figures have been based on unselected groups. There are some reports of higher correlations for other types of intelligence tests. Cornell and Coxe (4) found an *r* of .61 with *National Intelligence Test* scores on a group of 101 school children Morganthau (13) gave the Meiers *Mental Measure* to the group of 116 children mentioned above with a resulting *r* of 71 with the completion test We have no data so far on the correlation between the Wood *Completion* and the *Stanford-Binet*. The correlation ratio of 59 which we obtained between completion score and Kuhlmann-Anderson mental age on about 400 subjects from our total group shows some degree of relationship and was worked out on a more adequate sample than in many of the reported studies on the Healy test However, it has not the value of work based on individual rather than group testing and was necessarily derived from estimated mental ages and on only part of our age range Consequently we are not justified in placing too much emphasis upon it. It is interesting that this figure is 10 points lower than the *correlation ratio* between the test scores and chronological age based on the entire group of 1,026. The latter ratio of .69 corresponds quite closely to a correlation coefficient of .66 between chronological age and Healy score found by Cornell and Coxe (4) on a group of 234 school children. That the test seems to have a greater relationship with chronological age than with mental age has numerous implications which cannot be fully discussed in this article. If, as has been assumed, the completion test measures general adaptive capacity, we should hardly expect a high degree of relationship with the type of "intelligence" which is predicted by school success In a large group a somewhat higher correlation with life experience as represented by chronological age might well appear. The data for a comparison between the results on the unselected group used for this study and groups of unadjusted children is being gathered and may shed further light on this point.

In attempting to ascertain the reliability of the completion test the question of the most favorable interval between test and retest arose, and it was only after considerable experimentation that an interval of not less than 15 months or more than 18 months was selected. Because of the novelty and vivid quality of the test material, the recall of detail tended to be very marked even after a year's time, and of course was present to some degree at the time the retests were finally made. Especially among the children in the lower age ranges there was a tendency to "find the piece I put in before" instead of solving the problem afresh. In order to lessen the practice factor, the retesting was postponed as long as seemed possible without the element of maturation becoming too great a factor. Two hundred and fifty-eight subjects of the original group were retested with an average interval of 16.1 months. The distribution by age and sex appears in Table 13.

It will be seen that the entire age range is represented, although not evenly because of the difficulty in locating subjects where there had been a change in schools. However, the sample includes the entire range of scores on the first test. The correlation coefficient between the first and second test scores is .75. This, of course, is fairly high, especially considering the strong element of maturation which took place between test and retest and the extent of which is reflected in Table 14.

TABLE 13

Age at time of original test	Boys	Girls	Total
7/6- 8/5	10	12	22
8/6- 9/5	12	11	23
9/6-10/5	19	21	40
10/6-11/5	18	18	36
11/6-12/5	16	11	27
12/6-13/5	14	14	28
13/6-14/5	12	11	23
14/6-15/5	6	10	16
15/6-16/5	12	12	24
16/6-17/5	9	10	19
	128	130	258

TABLE 14

Observed score (X) Test I	Predicted score (Y) Test II
20	69
40	83
60	98
80	112
100	127
120	142
140	156
160	171
180	185
200	200

The error of prediction is ±26.6 points

$$Y = 54.3 + 0.73X$$

It was the original plan to administer the Healy *Completion II* to a certain proportion of the standardizing group at about the time of the first testing on the Wood test, but here again a large practice factor appeared Very high scores were gained on the Healy test when it immediately followed the other, and as it was not possible to equalize this by alternating the tests because of the necessity of using the Wood scores for standardization, this plan was abandoned Consequently the Healy testing was done in conjunction with the retesting on the Wood test. The average interval for the Healy group was 16.2 months and the number 234 The distribution of this group by age and sex appears in Table 15.

When the Healy scores were plotted against the Wood scores for

TABLE 15

Age at time of original test	Boys	Girls	Total
7/6- 8/5	10	12	22
8/6- 9/5	10	9	19
9/6-10/5	16	18	34
10/6-11/5	15	20	35
11/6-12/5	14	8	22
12/6-13/5	14	16	30
13/6-14/5	12	8	20
14/6-15/5	4	10	14
15/6-16/5	10	12	22
16/6-17/5	10	6	16
	115	119	234

the same group, there was some doubt about the linearity of the relation between the two tests. Also the fact that the Healy test has about half the range in score of the other might induce a curvilinear relation The linearity was tested through an analysis of variance, from which it was evident that no essential curvilinearity was present The correlation coefficient between the Healy and Wood scores is 53. The error of prediction is 14.5 score units Table 16 gives the predicted values of the Healy score based on selected values of the Wood test.

TABLE 16

Observed score on Wood Test	Predicted score on Healy Test
20	55
40	60
60	64
80	69
100	74
120	78
140	83
160	87
180	92
200	97

Since the correlation is so loose, it is probably not advisable to predict one score from the other.

The reliability coefficient of .75, while not sufficiently high to warrant prediction of individual performance, is fairly substantial considering the necessarily long interval before retesting. Since, in spite of the fact that the rate of maturation differs for different children, a correlation of this degree appears, by inference the value would be considerably higher if it had been practically possible to retest after a short interval Cornell and Coxe (4) retested 125 children on the Healy *Completion* after an interval of 11 months with a resulting reliability coefficient of .70, but apparently little has been attempted along this line. Morganthau (13) retested about 25 children on the Healy test after an interval of "a week or more" and abandoned the project because of the change in the attitude of the subjects. The second test proved to be "more a matter of memory than anything else" It is doubtless due to the difficulty in retesting with this sort of material that there is so little known about the reliability of the Healy test

The comparatively low correlation coefficient of .53 between the Healy and Wood tests makes it impossible to predict the score of one from the score of the other Several factors undoubtedly influenced these results The long interval between tests, the difference in range of the two tests, and the differences in type of scoring, especially in the matter of negative values. There seems to be no question that the Healy test is somewhat easier, and there is some evidence from the literature that the Healy norms are rather low. The type of test situation in both series is so similar in makeup, however, that it seems safe to say that there is actually more of a relationship between the two than this correlation coefficient indicates. Certainly the two tests may be used as substitutes for each other if not as true alternates

Pictorial material of this nature has certain definite advantages for clinical use, since its attractive character and novelty appeal to children of all ages The Wood *Completion Test* is applicable to a wide age range and to both boys and girls. The means of the age groups show a consistent age progression, the test being discriminative through the 16-year level, and deciles for each age level from eight to 17 years are available The test in itself should prove of value as an addition to clinic test equipment.

G SUMMARY

1. A need has been felt for a completion test which could be used for checking or retesting the performance on the Healy *Pictorial Completion Test II*

2. The Wood *Completion Test* is similar in form to the Healy test but presents a new set of problems

3. After several trial editions, sufficient data was accumulated from the use of the final form to demonstrate that the number of correct solutions increased fairly regularly by chronological age.

4. The test was administered to 1,026 public school children from 7 years 6 months to 17 years 5 months.

5. A semi-arbitrary scoring scheme was developed through a succession of steps based on statistical procedures.

6 Frequency distributions were made for each age level for boys and girls separately and the means and standard deviations computed.

7. Except for one age level, these did not differ significantly and consequently the boys' and girls' scores were merged into one group for each age level. Frequency distributions, means and standard deviations for the merged groups are given. Deciles were also computed for each age group.

8. A correlation ratio of .69 was found between completion test score and chronological age for the total group of 1,026.

9. Predicted scores for each year and month within the observed range were calculated. From these it is possible to obtain a mental age, although the deciles are considered more relevant norms.

10. A correlation coefficient of .59 was found between completion test score and Kuhlmann-Anderson mental age for 403 of the subjects.

11. Of the original subjects 258 were retested on the Wood test after an average interval of 16.1 months with a resulting reliability coefficient of .75.

12. Of the original subjects 234 were given the Healy test after approximately the same interval, the r between Wood and Healy scores being .53. This rather loose relationship is undoubtedly influenced by the difference in range and other factors. While it is not sufficiently close to warrant the use of the Wood test as alternate to the Healy test, the make-up of the two is so similar that one may certainly be used as substitute for the other. The Wood test itself should be a valuable addition to clinic equipment.

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THE USE OF PICTURES IN THE ESTIMATION OF THE SERIOUSNESS OF PROPERTY OFFENSES*

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A. INTRODUCTION

Developmental analyses of social attitudes or social concepts ordinarily require that these phenomena be studied in very young children, as well as in subjects of later elementary and secondary school levels. With adults or with children in the higher grades the ordinary verbal test or questionnaire methods can be used if they furnish data which are satisfactory for the particular problem involved But the use of these verbal methods does not solve the problem of obtaining comparable data from children below the fourth or fifth grade level, where reading ability is limited. It is necessary, therefore, to develop additional methods. This paper will describe one such method which has been found satisfactory for securing a ranking of property offenses from first and third grade boys.

The writer has been engaged in a study of the nature and development of attitudes toward property offenses in boys[1] It will be necessary to summarize briefly the objects and methods of that study in order to make clear the requirements a method for use with younger boys had to fulfill

The study was designed to throw some light on the tendencies which may be spoken of as an "attitude toward property" The data consisted essentially of the rankings of a series of 20 offenses against property by the paired comparisons method, treated in the method outlined by Thurstone (6) The writer wanted to find out what factors are responsible for the ranking of offenses against property, what changes take place in these rankings as the boy grows older, and what differences can be found between the rankings of delinquent boys and those of non-delinquent boys

The offenses used were selected from life histories written by

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[1] This study will be reported in detail in a later paper

delinquent boys and filed in the Institute for Juvenile Research in Chicago They were chosen so as to be familiar to Chicago boys of the socio-economic status used in the study. The 20 offenses used are given in the following list:

1 To swipe $1 00 from your brother's bank at home.
2. To help yourself to chocolates from a box in your sister's room
3 To borrow your brother's baseball without asking
4. To swipe your mother's wrist watch and pawn it
5 To lift $1 00 from your father's pants' pocket when taking the pants to the tailor.
6. To keep $1 00 you find on the street, without trying to find the owner
7 To take a wheel from a wagon you find in the alley.
8 To keep a candy package you find after it has fallen from a truck
9. To keep $1 00 you see a man drop from his pocket.
10 To keep a ball and glove you find in the school yard
11 To swipe flowers from a park.
12. To snitch three tickets from a movie cashier.
13 To steal candy and cigarettes from a boxcar.
14. To ride on the street car for half fare when you should pay full fare.
15 To sneak by an "L" cashier without paying
16. To take a wagon from a boy's back yard.
17. To swipe a dollar from your boss's desk
18. To snitch fruit from a peddler's stand.
19. To swipe and sell lead pipes from an old warehouse.
20 To sneak a rubber ball from a dime store counter.

The offenses were selected to represent four kinds of property: (*a*) property in the home (Offenses 1, 2, 3, 4, 5); (*b*) lost property (Offenses 6, 7, 8, and 10); (*c*) property having many owners (Offenses 11, 12, 13, 14, 15, 19, 20); (*d*) property owned by one person (Offenses 9, 16, 17, 18). Other variables are present in the offenses, however, and these include (*a*) value of the property involved, (*b*) nature of the term used to describe the offense (swiping, borrowing, finding, etc.), and (*c*) likelihood of punishment.

It was desired to secure rankings from representative groups of boys from the first grade through the twelfth For subjects in grade five and up a mimeographed booklet was devised in which each offense was paired with every other offense. The number of pairs resulting was 190, and the booklet eight and one-half pages long. (This booklet will hereafter be referred to as the "verbal test" to distinguish it from the "picture test" which was devised for use with Grades 1 and 3. The blank is not properly a "test," but the term is convenient) The items were so arranged that each offense was listed first in as many pairs as it was listed second, and the pairs were arranged in random order The directions on the blank were as follows:

> If we were asked, "*Which is worse, to rob a bank or to steal an apple?*" most of us would say, "*To rob a bank*" If we were asked whether robbing a bank was worse than shooting a man, some of us would say, "*Yes,*" and some would say, "*No*"
>
> In the following examples you are to decide which one of the two deeds printed together is worse and make a cross (X) in front of it If you aren't sure which is worse, guess Make one cross for every pair When you finish the first page go to the second

The paired comparisons method is particularly valuable for securing the summary judgments of a group of subjects, rather than for securing the judgments of an individual subject The blanks marked by subjects in the eighth grade, for example, are scored by tabulating, for each pair of offenses, the number of subjects who judged the first offense as worse than the second. From the resulting proportions a "scale-value" can be derived for each offense by the methods Thurstone has described (6). The unit of measurement for these scale-values is the standard error of observation, or, in other words, the standard deviation of a hypothetical distribution of judgments of the amount of "seriousness" separating any two offenses. The final score or scale-value of each offense indicates the position of that offense on a continuum of seriousness We are thus enabled to tell not only what the rank of the offenses in seriousness is, but also how much seriousness separates any two offenses on the scale

It was obvious that boys in the first grade could not read eight and one-half pages of written statements A little exploratory work soon showed that subjects of this age were equally unable to record their own judgments when the items were read to them They could not be depended on to distinguish consistently right from left, or an upper line from a lower line, nor could they follow the numbers of the pairs up to 190. When the writer tried reading the offenses to one subject at a time, and recording the judgments himself, two other difficulties appeared. (*a*) Three of the offenses seemed unfamiliar to the boys (streetcar half-fare, warehouse, boxcar); and (*b*) the boys appeared unable to remember the first offense long enough to compare it with the second. Eight or ten boys were used as subjects during this part of the work, and a strong tendency to choose the latter of two items was noticeable. When questioned on the first item the boys were frequently unable to remember what it was It was evident that satisfactory judgments could be given by first grade boys only if the two stimuli were simultaneously present This suggested the possibility of presenting the offenses visually, in picture form

B. PREVIOUS USES OF PICTURES AS TEST MATERIALS

The use of pictures as test materials is not new. The limited language ability of young children has made pictures especially suitable for use in intelligence tests; and intelligence tests designed for illiterates or for foreigners with a poor command of English have also shown pictures to be useful as test materials In general, however, picture-testing has been limited to this field of intelligence. Tests of character, personality, attitudes, and "moral comprehension" have usually been applied only to subjects who could read. The following studies are exceptions

McGrath in 1923 (2) used eight sets of pictures among her other tests of moral knowledge. They each represented an offense of some sort, and the child was given full score when he correctly diagnosed the section in the picture or pictures. The following pictures were included: (*a*) A beggar steals a loaf of bread for his son (*b*) A beggar picks a pocket in front of a theater. (*c*) Two pictures are used: one shows a quarrel at a card game, and the next shows one man shooting the other. (*d*) A pioneer in a log cabin is seen shooting an attacking Indian. (*e*) Three pictures are used: the first shows a church, indicating that the day is Sunday; the second shows three boys holding a conference in their Sunday clothes; the third shows them fishing (*f*) Three pictures are again used, a boy is seen beckoning to a girl, the two are next seen taking a walk, and in the last picture he is kissing her. (*g*) Two pictures are used to show a man kissing his wife and family goodbye, and then to show him in a cafe dancing with another woman (*h*) Several women are shown together gossiping The pictures as reproduced in McGrath's monograph are poorly done line drawings, filled with so much detail that the action is almost obscured She mentions this as one of the difficulties of using the tests

Pototzky (4) in 1926 used pictures of "primitive unambiguity" to test ethical feeling (*ethisches Empfinden*) His method was to present 12 pictures, six which normally arouse "positive" feelings (i e., pity, affection, etc.), and six which normally arouse "negative" feelings (i e, horror, disgust, indignation, etc) He then watched the child's facial expressions and noted his comments. Among his positive pictures were (*a*) a helpful child binding the finger of a small crying child; (*b*) a boy coming to the rescue of a little girl who is being beaten by two bad boys, (*c*) a coachman, in winter, covering his freezing horses. The negative pictures included (*a*) two boys teasing a cat by holding her tail and beating her; (*b*) two children stealing the crutches of a poor sick man who has fallen asleep on a bench; (*c*) a boy stealing apples from a fruit-dealer's basket Pototzky presents no results.

Woodrow (8) devised a picture-preference character test for primary children (1926) He used 11 sets of pictures, one set of four on each page of an 11 page booklet. Each set of pictures shows a graduated series of responses to a social situation. The pupils rank the four pictures on each page according to their preference for them as pictures, and mark their choices with crosses With one exception the four pictures on each page represented two desirable and two undesirable examples of the same trait The test is scored by counting against the child deviations from the averages of the nine-year-old group Woodrow reports a reliability of +.79 by retests, a correlation with mental age of +.48, and with character ratings around +.40

Mellinger (3, 1932) and Freeman and Freeman (1, 1933) have tested children's picture preferences by means of the paired comparisons method Mellinger presented only nine pairs of pictures at one sitting, using subjects from the first, third, and fifth grades The pictures were held up before a group of subjects, who recorded their judgments by drawing circles around the letters designating the pictures of their choice. The Freemans used only nursery school children, presenting the two pictures at one end of a box that was painted black inside. The child was told to watch until the light was turned on. Their sittings were only about five minutes long

Vance and McCall (7) in 1934 reported the use of a modified paired comparisons method with pictures to determine children's preferences among play materials. They photographed 48 different play materials, classified into eight groups of six items each The items in each group were paired with each other, but not with the items in the other groups, the number of pairs being thereby considerably reduced. After each group had been gone through individually, the best liked play items in each of the groups were paired with each other. The result was an approximate rank order of the 48 items for each of the 32 pre-school subjects. Group scale-values could not be obtained by this method. The pictures were placed two at a time under a glass frame in front of the subjects, and a preference was obtained. The 148 pairs of pictures which made up the total series were displayed in three sittings for the kindergarten subjects and in four sittings for the younger children At the end of one or two weeks the whole series was repeated to obtain an estimate of reliability. The reliability coefficients (obtained by correlating the total number of checks given each item at the test and at the retest) were +.78 for the four-year-olds, +.68 for the five-year-olds, + 95 for the sir-year-olds, and +.87 for the total group.

So far as the writer is aware the above studies comprise the only attempts up to the present time to use pictures as test materials for other than intellectual ability or aesthetic judgment. The use of pictures as stimuli in the paired comparisons testing for social values has not been tried.

C THE DEVELOPMENT OF A PICTURE TEST TO CORRESPOND TO THE VERBAL TEST

It cannot be assumed a priori that any picture drawn to illustrate such a statement as those in the list of 20 property offenses will produce the same reaction as the statement alone. The pictures used in the present study[2] were drawn in ink on 9 x 12 paper with only the essential details included. They were simplified as far as pos-

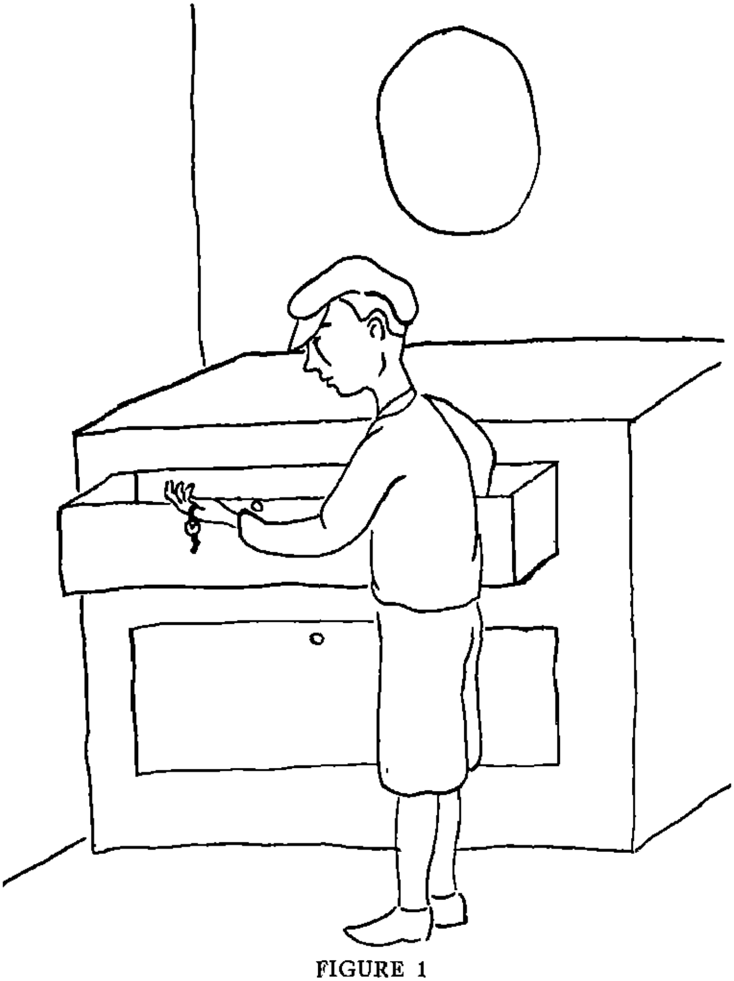

FIGURE 1

OFFENSE NO. 4 TO SWIPE YOUR MOTHER'S WRIST WATCH AND PAWN IT sible to correspond with the simple verbal description of the same event. The pictures of Offenses 4, 11, 16, and 18 are reproduced in Figures 1-4 to illustrate the general appearance of the drawings.

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[2] The writer is indebted to Mr Karl Gasslander, formerly of the Northwestern art department, and to Mr William Hughes for their assistance in designing and drawing the pictures

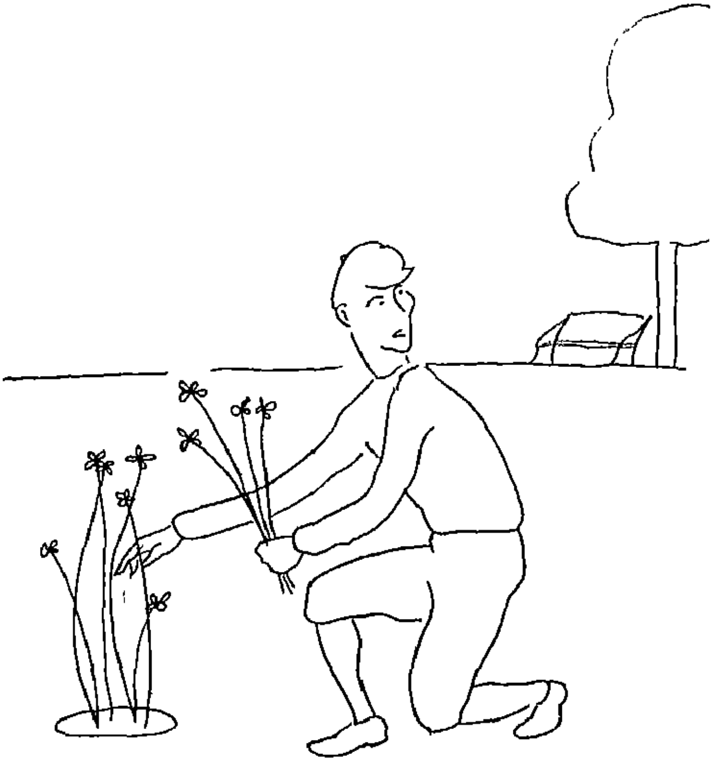

FIGURE 2
Offense No 2 To Swipe Flowers from a Park

During the preliminary testing only one copy of each picture was used, but later they were reproduced by mimeograph on 8½ x 11 paper and the pairs were stapled or hinged together. The mimeograph reproduction was used because it was inexpensive and because the simple outlines which resulted were quite satisfactory for the purposes of the present study All subjects were tested individually by the writer, and no third person was present at any time.

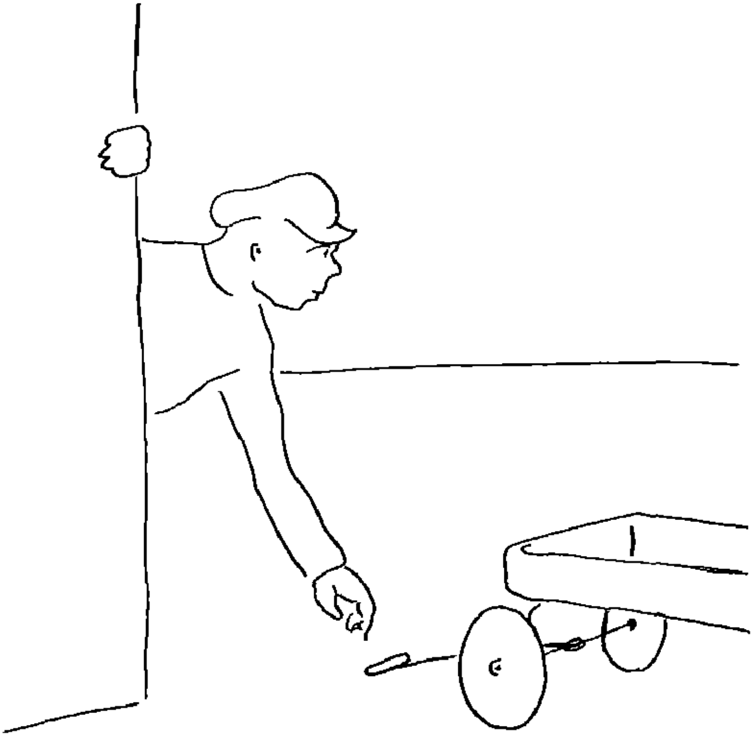

FIGURE 3
OFFENSE No 16 To TAKE A WAGON FROM A BOY'S BACK YARD

Instructions were given informally about as follows

> I want to show you some pictures of boys doing a lot of different things I'm going to tell you what each boy is doing, and I want you to remember as best you can so you can tell me if I ask you. Now, here are the pictures of two different boys. This boy (*indicating the one on the left*) is taking a wheel off a wagon he finds in the alley. Do you see? And this one (*on the right*) is swiping his mother's wrist watch Do you know what swipe means? That's right, it means *"steal"* Now look at both boys. Which boy is naughtiest?

The choice of the word *"naughtiest"* was made after preliminary

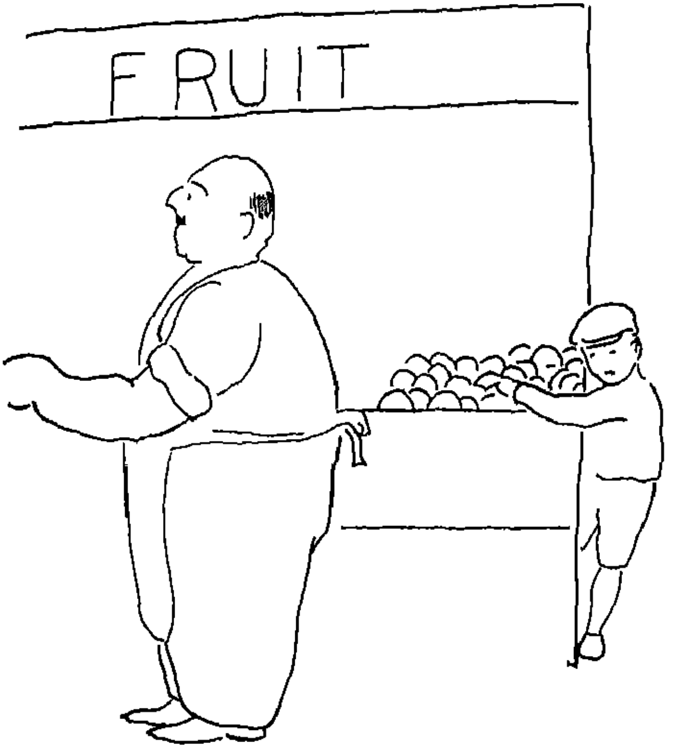

FIGURE 4

OFFENSE NO. 18. TO SNITCH FRUIT FROM A PEDDLER'S STAND

work showed it to be more generally understood than *"worse," "worst," "baddest,"* or *"naughtier."*

Responses were usually immediate. The judgment was recorded, and the second pair shown. Those pictures were explained and the question, *"Which boy is naughtiest?"* was asked again Each picture was explained the first time it appeared, and on the second appearance the subject was asked to tell what the boy in the picture was doing. If his version differed significantly from the correct one the experimenter corrected him. Subjects were required to explain the picture before expressing a judgment until the experimenter was convinced that they knew the offenses thoroughly.

Boys of any age are quick to make use of any cues given them by whoever asks them questions. They interpret glances almost as easily as they do actual pointing and other gestures To avoid giving cues in these individual tests, the experimenter found it necessary to observe the following precautions (*a*) when he asked, "*Which boy is naughtiest?*" he looked either at the subject or straight ahead at the wall, not at the pictures. (*b*) If it was necessary to explain one picture of a pair, both were explained with equal attention to each (*c*) When explanations of pictures were necessary (as in the first part of every sitting), the left-hand picture was always explained first. As each picture was on the right of as many pairs as it was on the left, this practice entailed no systematic space error

In order to secure an estimate of the stability of response to be expected from first grade boys, 25 pairs of pictures, selected at random, were presented twice to a preliminary group of 12 subjects For the second presentation the pictures were reversed in spatial arrangement—the right-hand picture in the first presentation became the left-hand picture when the series was repeated It was desired to discover how frequently the pictures judged the worse in their respective pairs would be judged the same at the second presentation Because the pairs were chosen at random, it will be understood that they varied considerably in the amount of "seriousness" separating their component offenses The pair made up of Offenses 4 and 3 (swipe mother's wrist watch and borrow brother's baseball), which offenses were consistently ranked as the most and the least serious respectively by the older subjects, is a sample of the paired items which are a long distance apart on the seriousness continuum. Offenses 18 and 19 (to swipe lead pipe from a warehouse and fruit from a peddler) were usually judged to be of equal seriousness. no distance separated them on the seriousness continuum It is obvious that judgments given for the former pair would tend to be more stable or consistent than judgments given on the latter pair But even with a series of pairs selected at random there should be a considerable amount of stability if the subject comprehends the task and conscientiously attempts to do as instructed Because the success of first grade boys in these aspects of the task could not be predicted a priori, the stability series was considered necessary before the picture test could be considered at all adequate.

The series of 25 pairs was given and repeated during one sitting of about 20 minutes The experimenter and subject sat at a table, the subject on the experimenter's left. The pictures making up each pair were simultaneously laid in front of the subject with instructions as on the previous pages. Because of the nature of the paired comparisons test the subjects were not aware that any of the pairs were repeated. For the 12 preliminary subjects the following numbers of pairs out of a possible 25 were judged the same in both series:[8] 22, 22, 21, 21, 21, 21, 19, 19, 17, 13, 13, 12. Since reversals of judgment would not be surprising on pairs of offenses close together in seriousness, perfect scores are not necessarily to be expected. From this standpoint the first nine scores above exhibit definite stability: the result could not have been achieved unless the subjects understood the task and made a sincere effort to carry it out. Because three of the subjects showed only chance success, and because such subjects should not be included in any determination of group rankings of offenses by the first grade, it was decided to include a repeated stability series of 25 pairs of offenses in the final test series. In this way subjects who failed to understand the task or to cooperate could be eliminated.

Because the administration of a paired comparisons series of 20 offenses (190 pairs) to first grade children would require at best two long sessions, and because some of the offenses dealt with situations unfamiliar to first grade boys, it was decided to eliminate five offenses and use only 15 in the final picture series. Offenses 13, 14, and 19 (to steal candy and cigarettes from a boxcar, to ride on the streetcar for half fare when you should pay full fare, and to swipe and sell lead pipes from an old warehouse) were dropped because they tended to be beyond the experience of first grade boys. Offenses 3 (to borrow your brother's baseball without asking) and 6 (to keep $1.00 you find on the street without trying to find the owner) were dropped in order to even up the property categories, and because they were difficult to picture effectively. The 15 remaining items gave a total of 105 pairs when each one was combined with every other one. This is a significant reduction from the original 190 pairs

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[8] These figures will hereafter be called "stability scores"

The 105 pairs just mentioned, plus a repetition of 25 of the pairs for a stability score, gave a total of 130 pairs These were presented to the first grade subjects in two sessions of 20 to 30 minutes each The fact that evidences of fatigue during this period were rare may be due to the interest aroused by the pictures

It was desired to secure in the stability score only a rough indication of the subject's comprehension of the task. In the older groups where reading ability and adequate vocabulary could be assumed to exist and where rapport was not so delicate a matter as in the case of the first grade boys, this measure was not necessary There were, of course, isolated instances of reading disability in these older groups, but these were not usual The offense-rankings of the older groups showed that there were distinguishable degrees of seriousness between most of the offenses Using the scale-values given by the 10-year-old boys, the 105 pairs of offenses were ranked in order of the "amount" of seriousness separating their component items Starting with the pairs of extremely discrete items (i e., items far apart in seriousness) every other pair was chosen to be repeated as part of the stability series of 25. The 25 most discrete pairs could have been chosen for this series, but this would have left the remainder of the test series, including the whole second session, composed of the less easily distinguished pairs This seemed undesirable from the point of view of maintaining the interest of the subjects

The final series of 130 pairs was given in the following order: (*a*) the 25 pairs of the stability series, (*b*) 15 other pairs chosen at random; (*c*) the first 25 pairs repeated in reversed spatial arrangement; and (*d*) the remaining 65 pairs presented in random order. Parts *a, b,* and *c* made up the first session and Part *d* the second.

D Relation of the Picture Test to the Verbal Test

In order to determine how closely the picture test corresponded to the verbal test, both forms were given to two groups of boys, 36 twelve-year-olds and 54 fifth graders, a total of 90 subjects The verbal test was given first in each case, with the picture test following after an interval of one month in the case of Group I (36 subjects), and after one week for Group II (54 subjects)

To save time the picture test was given to these subjects in groups of 10, rather than as an individual test. The procedure was as follows: 10 sets of the paired pictures were prepared with a verbal description of the offense below each picture, and the pairs were numbered from 1 to 130. A record sheet was mimeographed with blanks for name, age, etc., a paragraph of directions, and space for marking the right or left picture of each pair as more serious. The directions and the appearance of the record blank are given below.

> *WHAT TO DO.* You have been given 130 pairs of pictures. Each pair has a number on the upper right hand corner Each pair has two pictures, one on the left and one on the right. Each picture shows a boy doing something, *like swiping a rubber ball, or hiding a dollar bill, or something similar.*
>
> The first pair of pictures on the top of the pile is No. 1. Open it and look at the pictures Decide which of the two deeds shown there is worst. If the deed on the right is worst, mark an *X* under *"RIGHT"* beside the number 1 in the column below here. If the deed on the left is worst mark the *X* under *"LEFT"* beside the number 1. Then do the same for pair No. 2, and so on *till you have finished all of them. Mark only one X for each pair*

Picture on		Picture on		Picture on		Picture on	
LEFT	*RIGHT*	*LEFT*	*RIGHT*	*LEFT*	*RIGHT*	*LEFT*	*RIGHT*
1	1	41	41	81	81	121	121
2	2	42	42	82	82	122	122
3	3	43	43	83	83	123	123

The directions were read aloud to each group of 10 boys, and the method of recording judgments was further illustrated by use of the blackboard. The task proved not too difficult, and the high

TABLE 1

DISTRIBUTION OF STABILITY SCORES FOR 90 SUBJECTS WHO TOOK PICTURE TEST IN GROUPS OF 10

Score	Frequency
25	13
24	21
23	18
22	11
21	6
20	4
19	4
18	5
17	2
16	1
15	1
14	3
13	1
Mean 23 02	N · 90

stability scores achieved by most of the subjects indicated the degree of cooperation the experimenter received Table 1 shows the distribution of stability scores for the 90 subjects in these two comparison groups

It will be seen that the mean stability score for these 90 subjects is 23 02, indicating that most of the subjects were adequately stable. Tests with stability scores below 17 were not used in the comparison, a fact which eliminated six subjects, three in each group Three subjects had to be eliminated from Group II for other reasons,[4] so that the final numbers available for comparison were 33 in Group I and 48 in Group II The comparison of the two forms of the test was made in two ways. (*a*) the offense rankings of each of the 81 subjects in the verbal test were correlated with the rankings of those same individuals in the picture test; (*b*) the scale-values obtained for the verbal test by the 48 subjects in Group II were compared with the scale-values of the same group in the picture test

1 *Comparison of the Verbal and Picture Tests by Individual Rank Orders*

Rank orders of the offenses for both forms of the test for each subject were secured as follows· the test for Subject "*A*" was examined and the number of times he marked each offense as worse than another was tabulated. In the 20-item verbal test the number of tallies for the various offenses[5] usually ranged from zero to 19, for the 15-item picture test the range was zero to 14. From these tally totals a rank order of the 15 offenses was determined, and the ranks of the two forms of the test for each subject were correlated by *the rank difference method* (*rho*). The resulting 81 correlation coefficients reveal the degree of relationship existing between one subject's judgments on the verbal test and his judgments on the picture test. It must be remembered that the paired comparisons method is not primarily one for use in studying individuals, and that its chief advantage lies in the accuracy with which it permits the comparison of groups. The individual correlation coefficients presented in Table 2 should be evaluated with this fact in mind.

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[4] One subject failed to finish his verbal test, a second subject consistently marked the second item in each pair of his verbal test, indicating failure to understand or unwillingness to cooperate; and a third subject, in marking his picture test, gave about the same number of tallies to each of the offenses, a result that could be achieved only with a very careless or a random marking Ordinarily the fifteen offenses received from 1 to 14 tallies apiece, but this subject's offense tallies ranged only from 5 to 10, despite the fact that he had a stability score of 18

[5] The ranks of only 15 offenses from the verbal test were required for the comparison. These could have been obtained by tabulating the judgments on just those 105 pairs which contained the 15 offenses Rank orders obtained these two ways may differ somewhat, because the removal of five items will affect the remaining 15 items differentially To determine if these two methods of obtaining the rank orders altered the results significantly, both methods were used on the verbal tests for the 48 subjects of Group II, and the two sets of rank orders were compared with the ranks from the picture test The results will be presented in a later footnote

TABLE 2

Distribution of Rank-Order Coefficients between Picture and Verbal Tests (N = 81)

Size of rho	Frequency
+.90 to +.99	15
+.80 to +.89	21
+.70 to +.79	21
+.60 to +.69	11
+.50 to +.59	7
+.40 to +.49	3
Below +.40	3
Median: +.787	N: 81

The median correlation of +.787 between the picture test and the verbal test seems sufficiently high to indicate that individual judgments on the two forms of the offense comparison have a moderately high degree of commonality.[6] Since the study of which this report presents a part is concerned with group attitudes, examination of individual records on the test is valuable only for the light it sheds on the group results. The correlations reported here are the product of five factors: (*a*) the degree of equivalence between the offenses as verbalized and as pictured; (*b*) the "amount" of seriousness which separates the items for the subjects tested; (*c*) possible changes in the attitudes of the subjects toward the offenses during the interval between the two test sessions; (*d*) possible variations in attitude toward the tests from one session to the next, and in willingness to cooperate with the experimenter; and (*e*) chance errors. It is not surprising that the correlations are no higher than they are.

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[6] This median of +.787 represents a comparison of ranks from the picture test with ranks from the verbal test determined by tabulating judgments for all 20 items. When judgments on only 15 items in the verbal test are tabulated, and the resulting ranks correlated with ranks from the picture test (as was done with the 48 subjects in Group II), a slightly different result is obtained. In that group the median correlation when the 20-item verbal test is used is +.812; when the 15-item verbal test is used the median is +.791. The difference, though in an unexpected direction, is small enough to be ignored.

2. *Comparison of the Verbal and Picture Tests by Group Scale-Values*

The ultimate measure of the comparability of the two forms of the test is the degree of correspondence between group scale-values based on the two forms. The 48 subjects of Group II were used in this comparison. These scale-values were determined as previously indicated for all 20 offenses of the verbal test and for the 15 items of the picture test. The group scale-values for the two forms, together with the rank orders of the offenses as determined by the scale-values, are presented in Table 3. Figure 5 shows a graphic comparison of the scale values for the two forms.

The data from the table are seen more clearly in Figure 5. Al-

TABLE 3

Scale-Values and Rank Orders for 15 Offenses as Judged by 48 Subjects in Grade 5A for Picture Test and Verbal Test

Offense Number	*Verbal test*		*Picture test*	
	S-values	Ranks	S-values	Ranks
1	+ .55σ	4	+ .36σ	5
2	— .98	15	—1.36	15
4	+1.65	1	+1.43	1
5	+ .96	2	+1.04	3
7	— .82	14	— .99	13
8	— .59	13	— .60	11
9	+ .47	5	+ .33	6
10	— .14	10	— .003	9
11	— .36	11	—1.09	14
12	+ .14	7	+ .30	7
15	— .08	8	+ .06	8
16	+ .27	6	+ .61	4
17	+ .93	3	+1.11	2
18	— .11	9	— .52	10
20	— .41	12	— .67	12

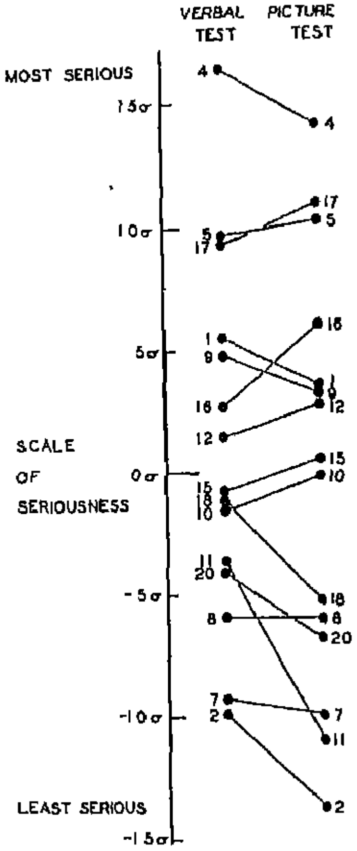

FIGURE 5

OFFENSE POSITIONS ON SCALE OF SERIOUSNESS FOR VERBAL PRESENTATION AND FOR PICTORIAL PRESENTATION

(Judges: 48 boys in Grade 5A. Connecting lines serve to clarify relationship.)

though the general position of most of the offenses is similar from one form to the other, there is a discrepancy in the case of two of the offenses—Nos. 11 and 16. Although the rank order correlation between these two sets of scale-values is +.957, which indicates a very high degree of relationship, it must be remembered that the scale-values are determined by the combined judgments of 48 subjects, and that as a consequence chance errors are much less likely to affect the results than they are where results from individual subjects are being compared It is therefore pertinent to look for the causes of the existing discrepancies

In the first place, it is probably impossible to create pictured stimuli that are completely equivalent, for a number of subjects, to the same number of verbal stimuli The discrepancies between the two forms are undoubtedly due to the differences in meaning conveyed by the two modes of presentation. If the reader will reexamine the pictures in Figures 2 and 3 illustrating Offenses 11 and 16, he will have as good a basis as the writer's for judging why Offense 16 ("*To take a wagon from a boy's backyard*") was ranked considerably more serious by picture than it was when verbalized, and why Offense 11 ("*To swipe flowers from a park*") was less serious by picture to the extent of three places in rank. (It must be remembered that changes in other offenses from verbal to picture form may have contributed to the apparent change in Offenses 11 and 16.)

It is interesting to note that Offense 17 ("*To swipe a dollar from the boss's desk*") gains somewhat more seriousness in the picture test than does Offense 5 ("*To lift a dollar from your father's pants' pocket*") In the picture illustrating the former offense a dollar bill is visible; in the picture of the latter the money cannot be seen because the boy's hand has not yet left the father's pocket It is possible that the sight of money in some way adds to the seriousness of the offense. When the subject's actual judgments are examined it is seen that in the verbal form 30 of the 48 subjects judged stealing from father worse than stealing from boss, and that in the picture form only 26 of the 48 judged stealing from father to be worse[7] The picture form thus does represent an increase in seriousness in the boss offense.

3 *Conclusion Equivalence of Verbal and Picture Forms*

The comparison of the picture test form with the verbal test form has shown that to a large extent the two give similar results. We are therefore justified in concluding that the judgments of the seriousness of property offenses as given by young subjects to pictured stimuli can legitimately be compared with similar judgments by older subjects given to verbal stimuli.

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[7] If this one set of judgments alone determined the scale-values of the offenses, the position of these two offenses in the picture test would be reversed, since 26/48, a majority, voted in favor of the greater seriousness of stealing from father. But the scale-value is a mean of a series of values in standard deviation units, and each of these values represents the judgments of the whole group on one pair of offenses.

E. Application of Picture Test to First and Third Grade Subjects

1 *Subjects*

The picture test described above was administered by the writer to 70 first grade boys and 43 third grade boys. All subjects were taken from two elementary schools in one neighborhood on the near west side of Chicago. The area in which the schools are located is one of the "interstitial areas" described by Shaw (5), in which a considerable percentage of the population is of foreign extraction. The economic status of all the people living in this area is quite low, although it is not the most poverty-stricken in the city. The amount of juvenile delinquency in this district is about midway between the highest and lowest rates in Chicago.

The ages of the subjects in these two groups are given in Table 4.

TABLE 4
Age Distribution of First and Third Grade Subjects

	First Grade		Third Grade			
Age	Total	Dis-carded	Failed retested individually group test;	Tested individ.	groups of ten Tested in	Grade Total Third
6	43	8				
7	23	6				
8	4		8	4	7	19
9			2	5	9	16
10			1	4	2	7
11					1	1
Totals	70	14	11	13	19	43

The meaning of the categories into which the table is divided is explained in the next section

2. *Stability Scores*

In the first grade all the tests were administered individually by the writer The method used has been described above

Of the 70 subjects in the first grade group, 14 had to be discarded before group computations were made Table 5 gives the reasons why these 14 subjects could not be used

TABLE 5
DETAILS REGARDING FIRST GRADE SUBJECTS WHO COULD NOT BE USED IN CALCULATION OF GROUP SCORES

Subject	Age	Stability Score	Comments
1 Joe	7	16	Judged first 25 pairs *R;* then, after being told the worse offense sometimes came on *R* and sometimes *L,* judged 8 pairs *L*
2 Louis	6	14	Gave judgments much more rapidly than other boys did; little or no time allowed to consider pictures
3. John	7	13	
4. Dean	7	13	Had spent two semesters in grade 1*B*.
5. Jack	6	13	Pairs 17 to 38 were all judged *L* Seemed more influenced by position than by nature of offenses
6 James	6	13	
7 Alphonso	7	13	
8. Paul	6	12	Had been used in preliminary testing, and may have lost interest at the end
9. Mike	6	11	Pronounced position habit, suggestible, no evidence of comprehending task, rapid judging
10 Tony	7	9	
11 Tom	7	7	Bad position habit
12 Casmir	6	Didn't finish	First 25 pairs marked on *L;* parents speak only Polish; probably language handicap.
13 Peter	6	Didn't finish	Slightly deaf, parents speak Italian only Knew meaning of "naughty", but not "naughtier".
14. Harry	6	Didn't finish	Judged *R* on first 20 pairs, teacher is failing him in 1*B*, and thinks he must be "a little subnormal"

It will be seen that all but three subjects are thrown out because of low stability scores These three (Casmir, Peter, and Harry) were so obviously not carrying out the task assigned that they were not allowed to complete even the stability series.

Cause for the lack of stability in these subjects can be assigned in only four cases, and only approximately there. Non-English speaking parents may explain the deficiency of Subjects 12 and 13; grade failure may indicate low intelligence in Subjects 4 and 14. The writer suspects that low intelligence is represented in some of the other cases, but absence of mental test data for the pupils concerned prevents a definite answer here. It should be noted, however, that the proportion of six-year-old boys to the total of first grade subjects is the same both for the discarded group of subjects (8 out of 14), and for the acceptable main group (35 out of 56) Evidently the ability required for judging the paired pictures is not above that of the normal six-year-old.

The stability scores of the 56 subjects who remained after the eliminations are given in Table 6.

TABLE 6
STABILITY SCORES OF 56 FIRST GRADE SUBJECTS ON PICTURE TEST

Stability score	Frequency
25	4
24	4
23	10
22	7
21	10
20	7
19	5
18	3
17	3
16	3
Mean: 21.04	*N, 56*

This mean stability score of 21.04 corresponds favorably with the mean for the fifth grade of 23.02.[8] It is to be expected that first grade subjects would be somewhat less stable than fifth graders. Nor is it surprising that a few first graders failed to comprehend the task well enough to complete the test.

In the third grade, to save time, an attempt was made to give the picture test to groups of 10 subjects at a time, as had been done with the comparison group in the fifth grade. The writer discovered, however, that some of the third grade boys were unable to master the group test procedure, and it was necessary to retest these subjects individually. In addition, a few third grade subjects were tested individually without any previous attempt to test them in a group Table 4, showing the age distribution of the third grade subjects, is divided into the three categories of (*a*) those who did not succeed on the group test, and were retested individually, (*b*) those who were tested individually without exposure to the group test procedure, and (*c*) those who were tested in groups of 10 The stability scores for these third grade subjects are presented in Table 7 in the same three categories.

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[8] In the fifth grade, of course, low stability scores were not discarded before the mean was calculated.

TABLE 7

STABILITY SCORES ON PICTURE TEST FOR THIRD GRADE SUBJECTS

Stability score	Frequency			
	Failed group test, retested individ	Tested individ	Tested in groups of 10	Total
25	2	3	1	6
24	6	5	2	13
23	3	1	7	11
22		2	4	6
21		1	3	4
20		1	1	2
19			1	1
Mean, 23 02	11	13	19	43

The mean stability score for this third grade group happens to be exactly the same as the mean score of the fifth grade The latter, however, includes six low scores which would undoubtedly have been raised if the subjects had been retested individually, as was done for the third grade Both of these means may be considered satisfactorily high for purposes of the present study

3 *Results*

The judgments of the subjects in Grade 1 were tallied and scale-values were calculated for each of the offenses, in the manner described on page 413 The judgments of the third grade subjects were similarly treated. Table 8 contains the scale-values and ranks for both groups of subjects. These data are presented graphically in Figure 6.

The general significance of these results for the analysis of attitudes toward property offenses is beyond the scope of this paper.

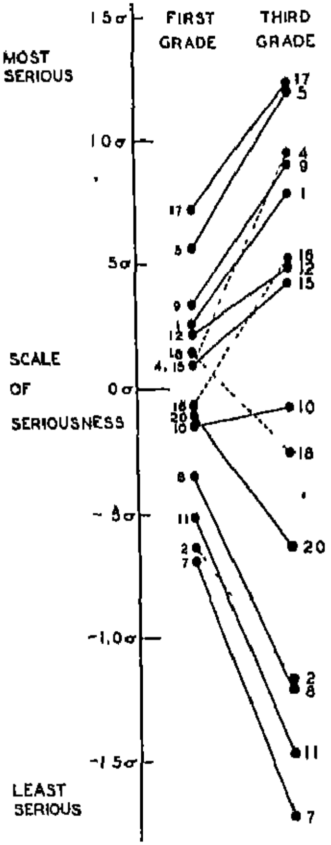

FIGURE 6

OFFENSE POSITIONS ON SCALE OF SERIOUSNESS FOR FIRST GRADE ($N = 56$), AND FOR THIRD GRADE ($N = 43$)

(Connecting lines serve to clarify relationship Broken lines used where discrepancies are greatest.)

TABLE 8

SCALE-VALUES AND RANKS OF 15 OFFENSES FOR GRADES ONE AND THREE

Offense Number	Grade one		Grade three	
	Scale-value	Rank	Scale-value	Rank
1	+.271	4	+ 796	5
2	— 638	14	—1.165	12
4	+ 102	7 5	+ 951	3
5	+ 571	2	+1 196	2
7	— 689	15	—1 724	15
8	— 351	12	—1 207	13
9.	+ 350	3	+ 904	4
10.	— 124	11	— 068	9
11	—.516	13	—1 470	14
12	+ 226	5	+ 494	7
15.	+.102	7 5	+ 433	8
16	— 067	9	+ 523	6
17	+ 734	1	+1 234	1
18.	+ 156	6	— 257	10
20	— 087	10	— 638	11

They are presented here to indicate the nature of the results to be obtained by this method.

Mention should be made, however, of the striking difference in the range of scale-values in Grades 1 and 3, as shown most clearly in Figure 6. The offense scale-values in Grade 1 cover a range of 1 423σ, and those in Grade 3 a range of 2 958σ. The latter range *is more than twice as great as the former. Such differences in the* range of scale-values are due to differences in the amount of agreement within each group In Grade 1 there was relatively less agreement as to which of two offenses was the more serious (on no pair of offenses was there unanimous agreement), but in Grade 3 there was considerable agreement. The 43 subjects in Grade 3 agreed unanimously on the more serious offense in each of 10 different pairs Had there been unanimous agreement on each pair of offenses (an impossibility without completely discriminable stimuli), the resulting range of scale-values would have been approximately 6 00σ

F. SUMMARY AND CONCLUSIONS

1. In order to compare judgments of first and third grade boys with those of older boys on the seriousness of 20 property offenses, 15 of the offenses were converted into simple line drawings These

drawings were reproduced by mimeograph, and were submitted in paired comparisons form

2. The 20 offenses in verbal form (190 pairs), and the 15 in picture form (105 pairs), were both submitted to two groups of boys to make possible a comparison of the verbal versus the pictorial form of presentation. The pictorial series followed the verbal series after intervals of one week (for 54 subjects) and one month (for 36 subjects) Results from these two groups, totalling 90 subjects, were as follows:

a In general the offense scale-values based on verbal presentation were similar to those based on pictorial presentation. The rank order correlation between these two sets of values was + 957.

b The median of the rank order correlations between the verbal and pictorial offense ranks for each of 81 subjects was +.787.

c The discrepancies between the scale-values based on the two forms of presentation were sufficient to indicate that the pictures were not completely equivalent to their respective statements for all subjects The similarities were so great, however, that the pictorial presentation was deemed satisfactory for use with subjects too young to understand the verbal presentation.

3. The 15 pictured offenses were paired and presented individually to 70 first grade boys, 14 of whom were unable to complete the task satisfactorily Forty-three third grade boys served as subjects, 24 giving their judgment's individually, and 19 in small groups. Each subject gave judgments on the stated 105 pairs of offenses, and in addition gave second judgments on 25 pairs which were repeated, unknown to the subjects, in reversed spatial arrangement. This "stability series" showed that the repeat judgments of the 56 first grade subjects duplicated their first judgments in 84.2 per cent of the cases, and that the first and second judgments of the third grade subjects were identical in 92.1 per cent of the cases. Since the subjects did not know they were giving repeat judgments, the results demonstrate comprehension of the task and an ability to discriminate between the offenses.

4 Scale-values were calculated for each offense and for each grade group by Thurstone's method. The results were not analysed in detail, but attention was called to the greater range of scale-values in Grade 3, which was accounted for on the basis of greater

agreement within the group on the seriousness of the offenses used

5 The conclusion seems warranted that pictures can serve as useful substitutes for words in the measurement of certain social values, when the subjects are below the age at which rapid and effective reading is possible.

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EARLY AGE DIFFERENCES IN MAZE PERFORMANCE IN THE ALBINO RAT*

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A Introduction

Studies of the early developmental changes that take place in individuals have been extensively carried on not only with children but also with rats, guinea pigs, opossums, rabbits, amblystoma, frogs, and other animals as subjects (cf , Murchison, 13, especially chapters by Carmichael, Pratt, Gesell, Shirley, and McCarthy Also Stone, 21). Those dealing with the early postnatal development of the white rat have reported such measures of maturation as the age at which the eyelids of the rat open (16), the age of the first eating of solid food (16), the age of the first appearance of sexual behavior in the male (18), etc. These changes are important in the development of the rat, and although they are often used as landmarks in an animal's development, they should be thought of only as observable changes in a continuum of developmental changes that are taking place.

Many studies have also been carried out on the chick in which the early developmental changes taking place with age have been studied by observation of the pecking and swallowing responses (3, 4, 5, 7, 12, 15) The effects of practice at different ages on these responses have been integral parts of many of these studies Likewise, the maze and problem box behavior of the chick have been studied by Cruze (8), and an analysis of the data shows that the chick improves significantly during the early ages in these types of behavior

The rat has been subjected to a series of studies in which age differences in maze behavior, problem box, and light box behavior have been studied. Watson (24) made an early study using a series of problem boxes and a very simple floor maze to compare the behavior of young animals (about 35 days of age) and adult animals (65 and 100 days of age) From an inadequately small number of

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animals in his groups he concludes that problems requiring physical activity for their solution were more rapidly learned by the young rats than by the adults. Those problems requiring control of movement for their solution were learned more rapidly by adults. In another part of his study, using very young animals, and again using inadequate numbers, he found observable differences in learning after 12 days of age with the older animals showing a superiority. He concluded that "the rat reaches psychical maturity at from 23 to 27 days of age" (24, p. 83).

Yerkes (25) in his work on age differences in the dancing mouse compared small groups of dancers of 1, 4, 7, and 10 months of age in learning and found that the animals at one month of age acquired a white-black discrimination habit more rapidly than did the older ones. *The older individuals, however, learned a maze more readily* than the younger ones.

Hubbert (10) reported superiority of young rats over old in her four age groups (25, 65, 200, 300, and 500 days) in maze learning, but her data as reworked by Paterson (14) show no reliable age differences between the groups to support her conclusions. Liu (11), using 30-, 45-, 60-, 75-, 100- and 250-day-old groups of rats, found that his 75-day group was superior to the others. The performance of the groups on the maze improved up to the 75-day group and then decreased. However, Stone (19, 20) in his age studies has given careful consideration to the factor of motivation in his various age groups and finds no consistent nor significant age differences between the ages of 31 and approximately 821 days.

Of these age studies Watson's was the only one which attempted *to probe the changes taking place in maze performance during the* early days of the rat's life. In his work, however, he not only used insufficient numbers of animals in his groups, but his mazes were of a design which would now be considered inadequate.

Improvement in adaptability to a situation is just as important from the point of view of development and maturation as are some of the more observable anatomical changes, and since little is known about this in the young rat, the writer believed that a measure of the animal's ability to adapt itself to a relatively complex situation, one in which improvement in performance could be observed, would be particularly significant in bringing to light more about the development of the rat. A simple water maze was the task chosen for use in comparing the groups of young animals.

B. APPARATUS

The pattern of the water maze used in this study is that illustrated in Figure 1. Six choice points were present in the correct pathway. The maze was a multiple-T pattern with walls and floor constructed of sections of galvanized sheet iron (No. 28 gauge). The walls were 12 inches high and the maze pathways were five inches wide. *S* indicates the starting point in the maze and *G* represents the goal, a bakelite platform above the water with an inclined landing approach which extended into the water. This platform was supported by metal legs 8½ inches high. The maze was situated in a glass tank 50 inches square by 14 inches deep. This tank, including the maze, was enclosed in a press-board box the ceiling of

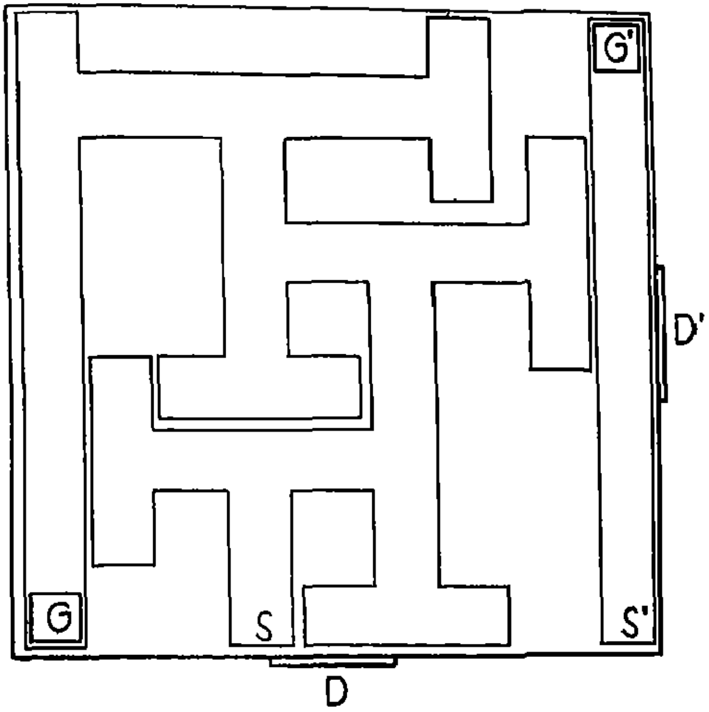

FIGURE 1
MAZE PATTERN

which was 48 inches above the floor of the maze. The tank itself was supported 29 inches from the floor of the room by four metal legs. The maze was lighted by nine 25-watt bulbs arranged at regular intervals in the ceiling of the box enclosure The water in the glass tank and maze was maintained at a depth of approximately eight inches.

A straightaway maze for preliminary training was also present in the glass tank This was 50 inches long and the pathway was five inches wide Whenever this straightaway maze was being used, the previously described landing platform was transferred to the area marked *G'* (goal) and the animals were inserted at *S'*. Two doors, each 12 inches square, were located in the walls of the box, one (*D*) just above *S* through which the experimenter reached when starting the animals in the T-maze at *S* and when removing them at *G*. The other door (*D'*) was located above the straightaway maze and was used when placing the animals in the straightaway and when removing them While observing an animal through one open door the other door was closed. The cabinet was used in an attempt to keep the environment of the animals while in the maze as constant as possible.

Although no attempt was made to control the temperature of the water, when tested at irregular intervals, it was found not to go below 28° *C* nor above 30° *C*. The tank was drained and refilled every two weeks.

The reliabilities of this maze as calculated by correlating the total errors on the odd trials with the total errors on the even trials for each of the four groups and applying the Brown-Spearman formula are as follows Group *A* = .00, Group *B* = +.77, Group *C* = +.68, Group *D* = +.46. Although several of these reliabilities are quite low, comparisons are made between the groups, for as Tryon has pointed out, "high reliability within the particular groups measured . is no necessary condition to the efficacy of an instrument in measuring group differences when actual differences between these groups are obtained" (23, p. 452).

C PROCEDURE

The white rats used in this experiment were of the stock of the animal psychology laboratory of Ohio State University Fourteen litters of white rats totaling 115 animals were divided by the split-litter technique into four groups. The division was made as soon as the eyes of all of the young within a given litter had opened. Twenty-eight animals (14 males and 14 females) were put into each of Groups *A*, *B*, and *C*, and 31 animals (16 males and 15 females) were put into Group D. The ears of the animals of each litter were punched for identification purposes at this time. The four groups of animals within each litter were raised together throughout the course of the experiment and were not weaned until they were 27 days of age

Training for one group, Group *A*, was begun as soon as possible after the eyes of all of the animals in any given litter had opened Until about this time the animal is not very proficient at swimming. The average time for the opening of the eyes was approximately 16 days after birth The training for Group *B* did not begin until exactly three days after that of Group *A*, or until the animals were 19 days old. The training of Group *C* began when the animals were 22 days of age and that for the animals in Group *D* began when they were 29 days of age

Two training periods were given the animals each day One was given between 8 and 10 A.M. and the other between 3 and 5 P M The training consisted of one trial on the straightaway maze during the first training period, four trials during the second period, and five during the third During the next period, training was begun on the Ţ-maze One trial was given at this time, but thereafter two trials per session were given until 24 trials had been reached. (In order to achieve this, only one trial was given during the last session) This means that the animals in Group *A* were trained on the Ţ-maze between the ages of 17 and 23 days, those in Group *B* between the ages of 20 and 26 days, those in Group C between 23 and 29 days, and those in Group *D* between 30 and 36 days.

The animals were partially dried with a towel after each trial when they had reached the platform, and were then returned to the home cage unless more trials were to follow during that session In that case the animal was placed back at the starting point of the apparatus being learned. If the animal had not reached the goal at the end of 10 minutes it was removed from the water. The reason for giving only one trial during the first training period on each maze was to eliminate the possibility of the animals getting so tired from the great amount of exploring which they did on the first trial that fatigue would unduly influence their scores on a second trial.

D. Results

On the basis of the data gathered on these four groups of animals, age comparisons in maze performance can be made in terms of the number of errors made by the groups, trials to reach a criterion of mastery, and time scores. All three comparisons will be briefly presented.

1. *Errors*

Error curves based on the mean number of errors per trial for the four groups of animals are presented in Figure 2. Differences between the groups are apparent although the difference between Groups *B* and *C*, the 19 and 22-day groups, is not striking. The curves indicate that Group *D* is superior to and makes fewer errors than Group *C*, this latter group is better than Group *B* and Group *B* in turn is superior to Group *A*. The curve for Group *A* does not reach as low a level as does any of the other curves and none of the other three drops as rapidly as does the one for Group *D*. The regular saw-toothed appearance of the curves through some of the trials is undoubtedly due to the fact that the animals were given two successive trials in each session.

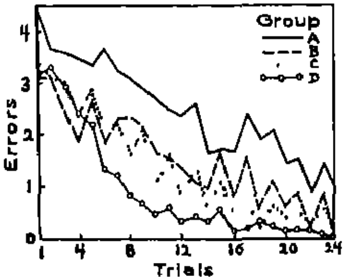

FIGURE 2
Means of Errors by Trials

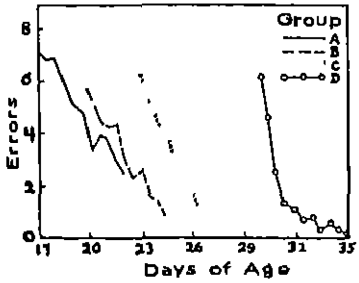

FIGURE 3
Means of Errors by Training Periods

The means of the total number of errors made by each of the four groups in the 24 trials are presented in Table 1. Group *D* has the lowest average error and Groups *C*, *B*, and *A* follow in the

TABLE 1

COMPARISONS BETWEEN THE MEANS OF THE TOTAL NUMBER OF ERRORS FOR THE FOUR GROUPS

				Differences between group means, their standard errors and critical ratios			
Group	Mean	*SD*	σ_M	Group *A*	Group *B*	Group *C*	Group *D*
A	58.46	8.18	1.55				
B	36.46	14.57	2.75	—22.00±3.16* —6.96**			
C	32.78	13.65	2.58	—25.68±3.01 —8.53	— 3.68±3.77 —0.98		
D	21.71	8.11	1.46	—36.75±2.13 —17.25	—14.75±3.11 —4.74	—11.07±2.98 —3.74	———

*The signs before each difference and critical ratio indicate which of the group means is the larger. A plus sign indicates that the group mean belonging to that row is larger than that belonging to the group indicated by the letter in that column. A minus sign indicates that the opposite is true

**The critical ratio is presented in the line just below the difference and the standard error of the difference order listed. Table 1 is also arranged to show the mean of each group in comparison with the mean of each of the other groups; it also gives the differences between the means and the standard errors of the differences The critical ratios obtained by dividing the differences by the standard errors of the differences are recorded just below these other two numbers Critical ratios of three or over are regarded as statistically significant.[1]

From an analysis of the critical ratios presented in the table it appears that all of the differences between the adjacent age groups are significant except the one between the 19- and 22-day-old groups All comparisons between non-adjacent age groups are significant. It is therefore apparent that the age variable has been an important factor in influencing the maze performance of the young animals used There is a gradual improvement with age within the age range used in the maze performance as measured by the error scores.

The data presented in each of the curves of Figure 2 were then combined into training session scores so that the total errors for Trials 2 and 3 were added together, those for Trials 4 and 5 were combined, those for Trials 6 and 7, etc. Curves showing this for each group are plotted in Figure 3 in such a way as to use the age of the animal during maze training as the abscissa and the average error by trials for the group as the ordinate. By drawing the curves in this way the differences in slopes of the curves or the differences in rapidity of improvement in performance of the groups are stressed. Likewise, the ultimate level of performance of the groups by the last training period, and the difference in number of trials that the groups perform at a good level of performance are also clearly shown. The scores for Trials 1 and 24 are necessarily omitted from the figures because of the experimental spacing of the trials.

It is also possible to calculate from the data the median number of trials to reach a criterion of mastery of two errorless runs out of three consecutive trials. Means for such could not be calculated because some of the animals had not reached the criterion in the 24 trials given. The median number of trials required by each group are presented in Table 2. The differences between these medians, the standard errors of the differences and the critical ratios, are also presented in the table. The critical ratios indicate that

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[1] The small littermate correlation in error scores which would lessen the standard error of the difference between the groups has been disregarded in the calculations because it would raise the critical ratios only slightly.

TABLE 2

COMPARISONS BETWEEN THE MEDIAN NUMBER OF TRIALS REQUIRED BY EACH GROUP TO REACH A CRITERION OF MASTERY OF THREE ERRORLESS RUNS OUT OF FOUR CONSECUTIVE TRIALS

Group	Median	σ_{Mdn}	Differences between group medians, their standard errors and critical ratios			
			Group *A*	Group *B*	Group *C*	Group *D*
A	21.50	1.29				
B	14.00	0.86	—7.50±1.55 —4.84			
C	12.00	0.86	—9.50±1.55 —6.13	—2.00±1.22 —1.64		
D	8.00	0.66	—13.50±1.45 —9.31	—6.00±1.08 —5.56	—4.00±1.08 —3.07	———

all the differences are significant except the one between the 19- and 22-day groups. The data here agree with the total error data in showing an improvement in maze performance with age throughout the ages used.

2. *Time*

The curves for the average time by trials for each of the four groups are presented in Figure 4. They indicate that Group *A* took longer average times to complete the maze than did Group *B*. This latter group took longer than Group *C* which in turn took longer than did Group *D*.

Table 3, which presents the means, their standard deviations, differences between the means, standard errors of the differences and critical ratios, indicates that the differences in time scores between all groups are significant. This further indicates that the differences in maze performance between the groups of animals are true differences.

When the curves in Figure 4 are plotted in such a way as to use the age of the animals during maze training as the abscissa and the average time by trials for the group as the ordinate, the relationship between the curves shown in Figure 5 is obtained. Again, as in the case of the error scores, the differences in rapidity in improvement of performance are striking.

TABLE 3

COMPARISONS BETWEEN THE MEANS OF THE TOTAL TIME SCORES FOR THE FOUR GROUPS

Group	Mean	*SD*	σ_M	Differences between group means, their standard errors and critical ratios Group *A*	Group *B*	Group *C*	Group *D*
A	1903 75	546 87	103 35				
B	883 82	437.39	82.66	—1019.93±62 04 —16 44			
C	674 04	323 76	61 18	—1229 71±83 30 —14.76	—209 78±55 58 —3 77		
D	470 84	196 07	35 21	—1432 91±97 17 —14 75	—412 98±74 79 —5 52	—203 20±50 03 —4 06	——

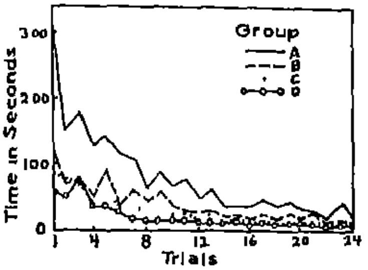

FIGURE 4
MEANS OF THE TIMES BY TRIALS

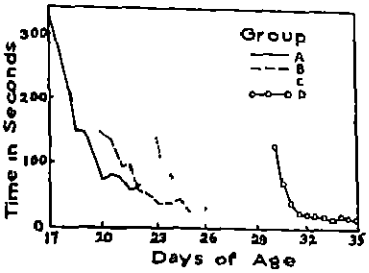

FIGURE 5
MEANS OF THE TIMES BY TRAINING PERIODS

E. Discussion and Interpretation

An analysis of the results obtained in this experiment has shown that there is an improvement in the maze performance of white rats when groups are tested at progressively older ages between the ages of 16 and 29 days. Several possibilities exist as ways of accounting for the differences found between the performances of these groups. In the first place, strength differences might possibly account for the differences found in maze performance. That is, the swimming itself might have been too difficult for the young animals and consequently they could not perform as well as the older ones. The older animals were likewise considerably larger than the younger ones. Differences of this sort undoubtedly played a part in the time scores and may possibly have played some part in the error scores. If strength did play a part in the error scores, then it would be a result of or a part of the maturation required for these young rats to perform well on this maze. However, these rats had been trained to swim through a straightaway maze to a platform in order to escape the water. During training on the straightaway and on the maze the animals escaped the water when they reached the platform, or, if they had failed to reach the platform at the end of 10 minutes they were removed from the water. Since the animals were able to swim or stay afloat for this length of time, and in many of the cases swam just as far a distance as they would have had to in order to reach the goal by the correct and shortest pathway, the actual differences in the swimming ability required to reach the goal seem of small importance.

One might presume that if the young animals could not swim as well as the older animals, there would be an increase in their muscular tension and energy expended in order to complete the task of getting to the goal. On the basis of such experiments as those of Carter (6), Bills (2), and others, with this increase in tension one might expect to find improved performance in the younger animals. Certainly in this experiment, the performance of the younger animals was not improved enough to appear in the results. On the other hand, there is some evidence to show that the beneficial effect of tension decreases as the complexity of the problem increases (2*a*). Certainly here the problem was difficult for the young animals and no benefits appeared in the results.

In the second place the differences found in performance might be due to true differences in learning ability between the groups In other words, these age differences in maze behavior may be due to an improvement in the functioning of the nervous system in the organization of responses in terms of a goal. The young might not have been able to learn the essential features of the pathway which would take them to the goal. Or, stating the situation in another way, the younger animals may not have been able to set up the platform as a goal toward which they should direct their activity. This latter possibility, although stressing the difference in motivation resulting from differences in learning to set up a goal, is fundamentally the same as the former, differences in learning being the basis of both. Regardless of preferences for ways of describing the situation, the fact remains that differences in maze adaptability among the animals at different ages existed (except in one case) and were apparent even when the ages at which the animals were tested differed as little as three days. Just what the underlying changes were which influenced this maze behavior, of course, is not known. However, there is anatomical evidence indicating that the number of cortical cells increases in the white rat up to approximately 21 days of age. There is also a general differentiation of the cell structures and a gradual change in the chemical composition of the cells going on during this time (1, 9, 17, 22). Changes in myelinization and total brain weight are taking place. It is entirely possible that these anatomical and chemical changes are related to the changes observed in behavior through either of the two reasons stated above.

Maze performance continued to improve with age in the groups tested, although some tapering off in improvement had begun to take place by the 29-day group. Just how long the improvement would continue with age cannot, of course, be determined from this study. Liu's work indicates that the improvement would continue up to about 75 days, whereas Stone's experiments indicate that the improvement with age would have reached its peak by 31 days or shortly thereafter.

F. Summary and Conclusions

Four split-litter groups of white rats were compared in their performance on a water maze. Their ages at the beginning of training were 16, 19, 22, and 29 days. Preliminary training was given on a straightaway maze. After the first trial on the T-maze two successive trials were given twice daily until 24 had been given.

All differences between the means of the various groups for error and time scores and trials to reach a criterion of mastery were significant, except those between the 19- and 22-day-old groups in error scores and trials to reach a criterion of mastery.

These differences indicate maturational differences which influence the animals' ability to adapt themselves readily to a water maze situation to such an extent that there is an improvement with age in maze performance throughout the ages used.

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SHORT ARTICLES AND NOTES

The Journal of Genetic Psychology, 1940, 56, 455-459

THE APPEARANCE IN THREE GENERATIONS OF AN ATYPICAL PATTERN OF THE SNEEZING REFLEX*[1]

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The purpose of this short note is to report the observation in a young woman of an atypical pattern of the sneezing reflex which was originally considered to be strictly a personal mannerism or habit of marked individuality The error of this assumption, however, was disclosed by the reappearance of this same peculiar pattern of sneezing behavior in her new-born daughter and the subsequent discovery that an essentially identical pattern was exhibited by the young woman's mother The situation which led to the making of this report was as follows:

> Close observation of the young woman over a period of years disclosed her sneezing behavior to be that of always expecting and usually experiencing, generally within one to two seconds, a second sneeze in rapid succession to the first Inquiry disclosed that this pattern of paired sneezes was of life long duration, that she had taken pride in it as a child, and that she could not remember ever having observed similar behavior in others, including her family In this last recollection, however, she was mistaken, since, after this study had

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[1] Previous to the submitting of this report, inquiry made of the young woman had found her mistakenly confident that no one else in her family showed this peculiar pattern of sneezing behavior Recently an opportunity for direct inquiry and observation disclosed that the sneezing behavior of the young woman's mother was essentially identical with that of the daughter and the granddaughter. Unfortunately, however, no day by day record could be secured Further direct inquiry disclosed no other instance of such unusual behavior in the family.

been completed originally, the author discovered by direct observation and inquiry the same peculiarity in her mother's sneezing behavior

As a consequence of this peculiar pattern of sneezing, the young woman has developed a definite modification of her general behavior, in that, on the occasion of a sneeze, she arrests her activity to await a second sneeze and, should it fail to occur, she experiences a somewhat distressing sense of incompleteness This same feeling of expectancy is also described by her mother.

Those fully aware of this young woman's oddity in sneezing tended to regard it purely as an individualism, an acquired habit based upon some chance occurrence in her early childhood, and fostered until it had become an ingrained habit. She, herself, regarded it as an innate, rather than as an acquired, pattern of behavior over which she had no control, constituting nothing more than an amusing physiological peculiarity and she offered the explanation that it might be similar in character to the sneezing reflex encountered in relation to bright light or to temperature changes

Exposure without her knowledge to nasal irritants, particularly substances to which she is allergic, does not alter this sneeze pattern, but serves rather to bring it markedly into relief, as does also upper respiratory infection.

In 1938, this young woman became a mother About three weeks later, upon her return home from the hospital with the baby, the infant was observed to sneeze twice in rapid succession No particular attention was paid to this except to note it casually During the next few weeks, probably because of various allergic reactions shown by the baby, many observations were made of paired sneezes in the infant and of the persistence, after the first sneeze, of the general muscular tension and facial grimaces suggestive of an anticipatory response to another sneeze, all very much in duplication of the sneezing behavior of the mother

When approximately two months old, the baby developed an upper respiratory infection and sneezed frequently and consistently in sets of two, with the time interval between sneezes never longer than a single, usually sharp, inhalation of breath. On relatively rare occasions, this inhalation would be spasmodic in character and then, instead of a single sneeze, there

> would be a series of two to six in rapid succession, a finding also true for the mother

When interest was first taken in the baby's paired sneezes, both parents began watching for singles. By the time the infant was three months old, a total of three single sneezes had been noted, while there had been scores of pairs. During the next few weeks, however, a constantly increasing frequency of single sneezes was noted and led to the making of a belated record of every sneeze heard This account was begun when the baby was slightly more than four months old. A similar record was kept on the mother, the two records differing only in completeness, since all of the mother's sneezes were listed, while only those heard by either of the parents when with the baby could be recorded. Unfortunately, however, no day by day record on the grandmother could be secured and it was necessary to rely upon careful inquiries As a control measure, close attention was paid to the sneezing of five other people, two of whom suffer from numerous allergies, to note the occurrence of paired sneezes. In addition, the author watched carefully for double or multiple sneezing among his numerous associates, but in no instance was a pattern of double sneezing discovered.

After the record had been kept for a considerable length of time, another peculiarity, not shown by the mother, was noted in the baby's sneezing, specifically, a light reflex sneeze This type of sneeze tended to occur upon sudden exposure to bright light, such as being taken out-of-doors into the bright sunlight, the turning on of the electric lights at night, or the sudden flashing of a bright light into the child's eyes, and, as far as could be determined, the distribution of single and paired sneezes followed the general pattern After making this discovery, the parents tended to avoid sudden light stimu-

TABLE 1
DISTRIBUTION OF SNEEZES

	Mother	Daughter
Single sneezes	32	125
Paired sneezes	105	212
Triple sneezes	17	20
Multiple sneezes (more than three)	4	5
Light reflex sneezes	0	20

lation, reducing somewhat the previous frequency of sneezes. In Table I, the sneezes listed as light reflexes are known instances only. In all probability, the actual total is greater.

Other observations made while keeping the record, which extended over a period of nearly four months, were that for both cases the ratio of paired to single sneezes remained essentially constant from day to day, and that upper respiratory infection and exposure to allergens served only to increase proportionately the frequency of both types of sneezes. It is also of interest to note that previous to the keeping of the record, the mother believed that only rarely did she, herself, sneeze singly. In addition, despite the close watch kept on the sneezing behavior of a large number of people, no similar pattern was found, although a few instances of occasional multiple sneezing were observed

COMMENT

Frequently in a specific type of behavior involving organic and psychic patterns of response, the differentiation is difficult between the behavior constituting a functioning of innate physiological and neurological processes and the behavior constituting a response of the personality itself to organic processes over which it may have little or no control. Nevertheless, the attitude taken by the personality may serve markedly to alter or to distort the strictly somatic aspects of the total behavior process and particularly is this considered to be the case when some relatively simple form of physiological behavior involving definite psychic responses manifests a striking individuality peculiar to the person.

Hence, when some process of physiological or neurological behavior shows apparently purposeless and illogical variations in accord with what could reasonably be expected to result from personality factors, the assumption is made that the personality has seized upon that innate behavior and added to it learned behavior serving other and remoter purposes of the personality, as is often to be noted in psychoneurotic symptomatology.

At first thought, this might seem to be the case with the young woman, especially so since her mother's sneezing behavior could furnish an opportunity for an imitative performance However, the appearance of the same pattern in the granddaughter long before the possibility of imitation, clearly indicates either an inheritance or a remarkable coincidence. In this connection, references may be made to the recent extensive experimental studies on the startle pattern by Landis and Hunt (1) who found that, "Complicated bodily responses exist and are exhibited in a pattern-like fashion—startle, Moro reflex, sneezing, coughing, and so on," and that the general pattern of these responses tends to remain constant regardless of age, sex, and race To this may be added that variations in the pattern may be inherited

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Eloise Hospital
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The Journal of Genetic Psychology, 1940, 56, 461-480

BOOKS

The *Journal of Genetic Psychology,* the *Journal of General Psychology,* and the *Journal of Social Psychology,* will buy competent reviews at not less than $2 per printed page and not more than $3 per printed page

Conditions Only those books that are listed below in this section are eligible for such reviews. In general, any book so listed contains one or more of the following traits: (*a*) Makes an important theoretical contribution; (*b*) consists largely of original experimental research; (*c*) has a creative or revolutionary influence in some special field or the entire field of psychology; (*d*) presents important techniques

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CRITICAL REVIEWS OF RECENT BOOKS

(*Goldstein, K. The Organism. New York: American Book, 1939. Pp. 519.*)

REVIEWED BY L. A. PENNINGTON

The author of this text has presented for the first time in English his systematic interpretation of human and infra-human activities. The book becomes essentially a technical discourse with numerous illustrations on the use and misuse of the scientific method by biologists, psychologists, physiologists, and medical men. The approach, at the same time, might well be said, from the mechanistic point of view, to be reactionary and to lead in the direction of supplying ammunition for those in the organismist's camp. For these and other reasons, the reviewer feels that a series of introductory statements setting forth the tenets believed to be basic in Goldstein's treatment will make for simplification in presentation.

These statements, tending to "place" the book, are as follows. First, the assumption that "simpler" infra-human subjects are more experimentally suitable for investigation is unqualifiably rejected. Because no one knows, except hypothetically, what behavior patterns are "simpler" than others, and because this approach has yielded controversial results, Dr. Goldstein starts his study with man as the animal to be investigated. In order to describe behavior in terms of "simplicity" or "complexity," we must know, he asserts, a great deal about the "natures" of numerous organisms. We know more, at the present time, about man's "nature" than we do about "rat nature," hence we should start with man and so avoid "insidious anthropomorphism." Dr. Goldstein further holds that pathological cases, made available both by dissection and analysis—the only methodological approach which natural scientists can use—afford unlimited opportunity in our studies of human behavior. Pathological materials are thus made partially equivalent as data sources with the experimentally modified biological specimens found in the laboratory. Experimental interference with "normal functions" is held thus so closely similar (in terms of performances of patients and operated animals) that observations made on both sources can be grouped together in a theoretical discussion. Second, the primary aim of natural science should be the detailed description of *all* the activities of the organism under known conditions in order to approach a more nearly complete understanding of the "essence" ("intrinsic nature") of an organism. Only in this way can the physician and the research worker, as proponents of the double aspect theory, ever come to a complete realization of the significance of symptoms, which represent, it is held, the reactions of any defective organism in its attempts to come to terms with environmental demands. Although a complete case history of the nature described is rarely, if ever, achieved, this goal should be forever present. Obviously this tenet implies freedom from all preconceived notions which might lead to the arbitrary selection of certain problems and of specific data. The scientist must rather record *all* phenomena. For this, the "plus and minus" method of recording is declared outmoded. Better to obtain a complete record of all successes and failures and the modes of action whereby each is achieved than to camouflage with plus and minus signs. The scientist, too, must be able to explain not only those data which are most appealing in terms of a preconceived theory of which are most frequently met but also all data collected. An analysis thus becomes adequate only when all observations can insure the development of an all-inclusive theory upon which prediction may be made. Adequate analysis in the early stages of research will, therefore, prevent future conflict in the development of modifications in theory in face of new accumulations of experimental data. As a corollary of this emphasis upon adequate analysis it is to be inferred that a multiplicity of cases would not be essential. Complete analysis of one well-controlled case would be superior to inadequate sets of observations obtained from many cases. In this connection Dr. Goldstein reiterates that the modifications in behavior shown by pathological cases with brain tumors and cerebral lesions will present characteristics in common with deduced laws applicable to both normal and pathological behavior. Further, it is Dr. Goldstein's opinion that by complete analysis of pathological and normal reactions of primates the scientist will be able to formulate a single ever-constant principle which will characterize the "essential nature" of the organism in a given figure-ground reaction (organism and the psychological environment). It is toward the development of this one basic constant for man that the methodological treatment of the book is directed. In the opinion of the reviewer this aim is achieved by continued reference to illustrative materials each of which leads to the same conclusion, namely, that the "nature" (defined as psycho-somatic constitution) of the organism is once and for all shown by the *performances* which the organism makes in "coming to terms in the *best*[1] way" with the "demands of the environment." Thus the organism's performances are stressed as primary symbols, which, if correctly interpreted, will lead to a complete understanding of *ordered* and *disordered* (i.e., *Catastrophic*) behavior. From this it follows that not only disordered but also ordered reactions of the structurally modified subject must be studied. Both sets of data are vitally important in the establishment of laws by means of which the medical man may predict future performances in terms of anticipated environmental demands. Third, each case, pathological or normal (that is, "ordered"), tends in any environment *to direct* its performances in the presence of structural defects, making it possible for the psychopathologist to comprehend the peculiar, fanatic orderliness in hospital behavior of patients with brain injuries. Their persistent avoidance of disorder may be looked upon as a defense or protective mechanism which prevents the appearance of castatrophic responses in an environment whose demands have been already recognized by the patient to induce disordered anxiety reactions. So, too, may the psychopathologist understand the ease with which certain memories are reinstated in pathological cases when the original environmental conditions are duplicated, as opposed to the opposite types of reactions when the environmental situations are quite different from those under which learning occurred. The patients thus attain a state of order by restricting their environments and so maintain an optimal level of performance after cerebral injuries. Compensatory reactions, to illustrate by reference to a case of hemianopsia, make possible clear vision even though the calcarine area of one hemisphere has been ablated. Here, too, is a demonstration of Dr. Goldstein's observation that the compensatory reactions may constitute covert devices which elude the neophyte investigator. Only when both calcarine areas are removed do we get true catastrophic behavior which is strikingly at variance with the ordered behavior following partial removal of the visual areas. Thus the most important function of the given system for the preservation of the organism is the last to be interfered with. One is reminded in this connection of Lashley's principle of all or nothing function developed by recourse to data obtained on the rat's visual system.

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[1] Defined apparently as general tendency or drive to realize optimal performance with minimum energy expenditure

Next, Dr. Goldstein refutes the basic assumptions made by the reflexologists who have rejected contradictory data obtained from human subjects by Dr. Goldstein and others. This refutation is based upon the experimental fact that varied responses may be elicited by the same physical stimulus applied to the same body areas. Further, as Dr. Goldstein states, the reflex appears "to depend on the value of the stimulus" by which apparently is meant the functional significance of the stimulus for the whole organism. Investigations are enumerated to indicate the manifold interrelation of the multitude of factors which influence the life processes. Interaction becomes the rule rather than the exception. It is concluded that it is impossible to attempt the isolation of a single factor and to consider it the single and constant determinant of a given response. Thus, nowhere can Goldstein find a single stimulus-response relationship which correlates with the necessary rigidity in behavior postulated by the reflexologists. The reflex becomes merely "a tendency of a relatively *isolated* part of the organism in its totality to return to a preferred position in response to the demands of the environment." The reflex is merely a means of functional equalization of demands. The conditioned response, in turn, is a complicated behavior pattern rarely met in normal environmental situations. It cannot be considered an adequate basis for understanding the performance of the whole organism. The conditioned response is thus the result of artificiality of the experimental conditions. As a corollary of these comments Dr. Goldstein goes on to point out that the reflex theory fails to explain in positive terms how it is that behavior is *directive* (as illustrated by the rejection or acceptance of an apprehended stimulus object), or is guided, in other words, toward an end. This characteristic of direction is the *most* outstanding attribute of all performances of the human organism. Whence comes this characteristic? Surely not from the environment, since the term environment is meaningless without the organism. The individual comes first and only then the environment. Hence, *direction* is given by the "conscious" organism which actualizes its "essential nature" and so achieves "wholeness." One might well at this point raise the question both as to the meaning and the origin of this single basic drive. One might also wonder what has become of the reciprocity principle used by Goldstein in his critical analysis of the reflex doctrine. One might even add that the organism, too, is meaningless without an environment. Such, however, seems to be the "nature" of Dr. Goldstein's holistic interpretation which scarcely manages, it seems, to avoid being teleological and indeterministic in certain of its fundamental tenets.

On these bases, as offered in a brief way above, Dr. Goldstein erects a theoretical system by means of which both normal and pathological data obtained from human subjects may be explained The essence of the theoretical interpretation is to be found, in the reviewer's opinion, in the third chapter of the text Here is presented a discussion, the aim of which is to deduce the nature of neural events concomitant with function and content. By means of these deductions based upon performance phenomena Goldstein believes the stage is ready for his formulation of a positive theory of behavior in terms of the whole organism. In the formulation, however, *he has dismissed physico-chemical factors, since, it is stated,* they cannot be said at this state in our knowledge, to play a specifically significant rôle. This interpretation might even now, it is believed, be questioned in spite of the fact that some of these data do not lend themselves easily to coherent evaluation Dr. Goldstein, nevertheless, maintains throughout his text that "life processes are properly conceived" only when performances of the total organism are investigated and when laws are deduced therefrom relative to the cause of neural excitation and the accompanying overt reactions. The theory is based, therefore, upon the assumption that the nervous system, both vertebrate and invertebrate, is a network in which ganglia are interposed at various places, and which network is related to the outer world by means of sense organs and the movable parts of the body. This network is assumed always to function as a whole. To the "energy" *excitations and transmission* are related the performances of the whole organism. The particular form of this relation, however, cannot yet be clearly described

The laws of neural function deduced by Goldstein follow First, the system is never at rest, but is in a continual state of excitation Any event upon stimulation becomes merely an expression of a change in excitation within the nervous system Second, a given stimulus produces changes in the whole organism These changes can be observed only in certain regions of the organism because in any extensive system changes cannot occur simultaneously and to equal degrees. Thus the "local near effect" is used as a term to designate the greater intensity of stimulus effect within a restricted area. The spreading of the *energy* (whatever is its nature) throughout the network is made possible by the ganglion cells which affect a channeled distribution of the excitation after the manner of metabolic gradients posited by Child and his students. Ganglia thus cause a relative delimitation of the extension of excitatory changes as compared with a system in which the ganglia have been removed. They make, normally, for a more localized effect. Indeed, these ganglia are said to cause a decrease of the excitation at the point of stimulation because here an equalization takes place between the higher excitation level and the lower level in the rest of the system. The "result is the gradual decrease of the reaction at this point—the "equalization of the excitation." The average excitatory state thus follows the excitation "after-effect" which in turn modifies later reactions Corresponding to the "local near effect" is the "functional near effect" which includes the fact that certain structures are more easily stimulated by certain physical stimuli than are others. "An adequate stimulus which impinges on any point, thus becomes effective at very different, widely separated regions, whereas other parts of greater local proximity but of different stimulus adequacy, remain relatively untouched" (p. 107). Equalization of excitation occurs in a temporal order and can thus be used as a physical principle underlying the accepted fact that one stimulus can effect performances having temporal sequences. Normal reactions become linked to normal structure by virtue of anatomical adequacy for specific stimulation and by virtue of specific practice. These structures, of course, illustrate the basic principle already stressed by Dr. Goldstein, and so can best be understood as a result of a process of the organism's coming to terms with the demands of the environment.

> The pattern of the excitation which occurs in the system, as a result of a stimulus, cannot be sufficiently characterized by noting merely the state of excitation in the "near part" The rest of the system, the "distant part," is also in a very definite state of excitation Each movement of one part of the body is accompanied by a definite change in the picture of the rest of the body. The change in the distant part is, in a certain sense, antagonistic to the first, and is necessary, not only for

> the maintenance of the balance in the entire system, but also for the accurate execution of the required performances

Thus, on these bases Dr. Goldstein formulates a structural substratum for the psychological concept of the figure-ground relationships

> The reaction at any one point of the organism is the more accurate if it is in configurational contrast to the rest of the organism--the more it stands in the "foreground" as compared with the "background" (represented by the rest of the organ-system) Whenever we analyze the structure of performances we meet this same configuration I am therefore inclined to regard this configuration of excitation, the foreground-background relation, as the basic form of the functioning of the nervous system (p 110)

On the behavioral side, study of cases reveals that injury to the nervous system impairs the execution of separate actions first, while

> more generalized reactions, corresponding to a less clear figure-ground formation, may still be present All this can be understood if we realize that a normal substratum is needed to maintain a high tension in a localized area and that this tension is necessary for the execution of discrete performances Any slackening of function leads, therefore, to a level, i e, to *a greater uniformity of processes in the concerned regions of* the system, or possibly in the entire system

The rôle of this figure-ground neural substratum is next considered As in "attention," so here, too, one finds a continuous alternation as to which "part" of the organism stands in the foreground and the background. The foreground is determined (*a*) by the task which the organism has to fulfill at any given moment, i e ,by the situation in which the organism happens to find itself, and (*b*) by the demands with which it has to cope (p. 111)

> "The tasks are in turn determined by the nature of the organism . which is brought into actualization through the environmental changes acting upon it The expressions of this actualization are obviously the performances of the organism. Through them the organism can deal with the respective environmental demands and *actualize itself* [*its own nature* (reviewer's italics)] The possibility of asserting itself in the world, while *preserving its character*, hinges upon a specific *kind of 'coming to terms'* *with the environment* This has

> to take place in such a fashion that each change of the organism, caused by environmental stimuli, is *equalized after a definite time,* so that the organism regains that 'average' state which corresponds to its nature, which is 'adequate' to it *Only when this is the case is it possible that the same environmental events can produce the same changes.* . Only under this condition can the organism maintain its constancy and identity' "If this relative constancy did not exist it would not even be possible to recognize an organism as such, we could not even *talk of a specific organism* This kind of coming to terms of the organism with the environment we call the *basic biologic law*" (p. 112).

Again on the nature of the environmental stimulus, Goldstein states "the only events which normally prove themselves as stimuli are those with which the organism can come to terms" in a manner such that its existence (the actualization of performances which constitute its nature) is not essentially disturbed. Thus each organism has its own milieu. One is reminded here once more of Dr. Goldstein's interpretation of behavior of patients suffering from brain injuries

This theory of neural function, it is stated, is compatible with known anatomical facts—although the nature of these facts appears to be unclear It is doubted, states Dr. Goldstein, that the anatomical structures described by histologists are at all essential for neural function. Anatomy cannot thus be said to supply completely firm foundations for any neurological theorizing. What neurological facts support Goldstein's theory are not mentioned.

The author of this text is thus able to explain the reactions of clinical cases in terms of the effects of stimuli upon the tendency toward physical equalization of the organism. Any reaction is significant, since it gives us information relative to the way in which the patient comes to terms (returns to an average state of functional equilibrium) with its own environment Thus, when the drive to self-actualization is blocked and when the return to the equalization plane cannot be achieved, catastrophic or disordered reactions occur. By a process of learning the patient soon comes to avoid such stimulating situations and so to restrict once more the extent of the stimulus influence, his milieu. Such restrictions become protective agencies by means of which catastrophic reactions are avoided. The fact that the neural theory presented by Dr Goldstein is not ham-

pered by assumed experimental facts of anatomy, of course, makes possible the establishment of this theory of functional organization of the entire nervous system into a totally reactive connective system. In this way he is able to explain both the labile and the perseverative responses of pathological cases. These reversals in performance need *not, therefore, be explained by appealing to concepts of hierarchical* "higher levels" assumed by some to mediate whatever each means by an "attention factor."

The balance of the book may be considered, from one point of view, to consist of an elaboration and an application of Goldstein's holistic *approach. The problem of instinct and drive are so treated* in some detail. The status of brain localization is reviewed and critically evaluated. It is maintained, to illustrate, that destruction of one part of the brain never leaves unchanged the activity of the rest of the organism. A shift in the distribution of energy excitation usually occurs. Qualitative and quantitative data must be collected in all such studies. We, further, cannot infer directly from a relationship between a localized defect and a functional disturbance, a relationship between *area* of lesion and a *performance.* Localization of a performance must rather come to mean "a dynamic process which occurs in the entire nervous system, even in the whole organism, and which has a definite configuration for each performance" Thus *while structures are known to exist the qualitative functional aspect* does not exist outside the *whole.*

An analysis of Freudian psychoanalytic theory results in its rejection. The theory of repression is supplanted by the holistic interpretation based upon the developmental sequences of the organism. *Repression does not exist.* The neural "after-effects" of early experiences, not completely integrated, are covered up by more recent actualizations of man in his coming to terms with an expanding cultural and physical milieu. All early experiences can be recalled provided man is brought into a situation similar to that under which *they originated.* Freud is thus accused of treating his data selectively. Unconsciousness is naught but the entering of a former reaction pattern into the present when *the situation is suitable.*

In summary, this book, for the reviewer, presents Dr. Goldstein's interpretation of human behavior in a complete fashion For those working in similar fields and for those familiar with the intricacies of the theory the present review may well appear to be incomplete

The reviewer's purpose, however, has been one of selection and placement of the work as it appears to him. Certainly for those working in related fields a careful reading of this stimulating text is recommended.

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(Pratt, C. C. *The Logic of Modern Psychology*. New York Macmillan, 1939. Pp. 185.)

Reviewed by Ralph W. Erickson

In this work Professor Pratt makes a bold attempt to bridge the gap from psychology to philosophy by making use of operationism and logical empiricism as a logical basis for psychology. He is clearly aware of the fact that the opposition of many psychologists to philosophy does not eliminate philosophical concepts but merely drives them underground. It is therefore refreshing to find an author who is willing to discuss some of these basic concepts openly, when it is so fashionable to conceal them under the name of "science" as *though their opponents' philosophical views were unscientific.*

The first thesis of the work is the essential monism of scientific data in which Professor Pratt first points out that it is impossible to get a general agreement as to what is mental and what is physical. Wundt tried to define the mental in terms of *immediate* experience, but Brentano ruled out Wundt's sensory contents as being physical and restricted the mental to psychical acts. Titchener and Külpe had both psychology and physics starting from the same world of experience, the difference between them being merely in the point of view. Finally Watson produced a behaviorism which was similar in pattern to the Wundtian psychology, with reflexes in place of sensations. From this the author concludes that there is no essential difference between mind and body, for there is no valid criterion to mark them off. This is followed by a discussion of various types of monism such as the neutral, the physical, and the psychical, but the author does not commit himself to any particular one. The dualistic position, however, and the various criteria between the physical and the mental presented by Professor Lovejoy are completely ignored. He does not consider the common observation that mental events do not follow physical laws, or as William James stated it, that mental fires do not burn real sticks and mental knives do not cut real wood. Instead he merely holds arbitrarily that there are no criteria to separate the two, with the result that no science can be defined in terms of subject-matter as *all start from the same* world of experience. The different sciences are merely divisions of scientific labor with considerable overlapping, but no criteria of separation are given.

The author next takes up various objections to the thesis that mind and matter are indistinguishable. The first objection considered is the common-sense view that we have an intuitive knowledge of a self, which is answered by pointing out that science tries to explain events in terms of the responsible conditions. It follows that the self cannot be identified with any of its physiological conditions. This answer may be true as far as it goes, but the author does not seem to realize that his answer would be equally true on a dualistic basis. There is nothing in the principle of causality that forces the causal relations to be between physical events, mental events, or mixtures of them. The second objection is concerned with the doctrine of transcendentalism in that psychological events have a reference beyond themselves, have meaning, value, and purpose which cannot be dealt with by science. To this objection the author replies that this doctrine is barren and negative and really attacks science in general. This appears to be the weakest part of the discussion so far as his thesis is concerned. The fact of transcendance is admitted, the question is whether the explanatory mechanisms are adequate to account for them. Few dualists would deny that present ability to think of past events (transcendance of time) is conditioned by present events in the brain. The arguments in this chapter, therefore, contribute nothing to the contention that mind and matter are identical.

In connection with his discussion of the behavioristic attack on transcendentalism Professor Pratt presents a very good defense of introspection as a scientific method. To the charge of Professor Lashley that introspection is an example of the pathology of scientific method, it is reported that all scientific observation must then be pathological for introspection does not differ in any essential detail from the observational methods of other sciences. There is no essential difference in reporting the presence of a red color and reporting the movements of a rat in a maze. Both methods collect data which in themselves are of no value to science except as they lead to explanatory mechanisms. In this way the author is more consistent than the behaviorists who give away their position by refusing to admit mental data into their system, thereby recognizing that there is a difference between the physical and the mental. The author, however, denies that there is any difference between them and accordingly admits all kinds of data, which are eventually to disappear when physiology explains them.

The third chapter is entitled *Logical Empiricism (Operationism)*, The title suggests that the two terms are synonomous, but the author makes a clear distinction and gives a clear account of these popular movements. The logical empiricists are concerned primarily with the analysis of scientific language, but also have the doctrine that propositions have meaning only if they are verifiable. Operationism, on the other hand has developed from Professor Bridgman's contention that the meaning of a scientific concept is determined by the operations carried out before it came into use. This is illustrated by examples from physics followed by a discussion of the importance of equations in defining concepts.

The author now applies operationism to psychology, although in so doing operationism is broadened practically to logical method in general. There is a discussion of the collection of data, of inference from the data, and deduction from these inferences. Applications of the first and third of these to psychology are presented first, while psychological inferences or explanations are considered in the following chapter. With regard to deductions in psychology, it is pointed out that psychology is not yet in a position to use them to any marked degree, as generalizations are apt to run beyond the empirical data and many of the relevant factors cannot be observed or controlled. With regard to the collection of data there is a protest against the unwarranted exclusion of data by the behaviorists. Professor Tolman admits in one place that both physics and psychology arise from the matrix of direct experience, yet in another place holds that psychology has nothing to do with immediate experience. The behaviorist is so afraid of the latter that he rushes blindfold into emphasis on objectivity, not realizing that all sensory data including that of classical psychology are just as objective as that of behaviorism In addition, it is pointed out that all phenomena are private, so far as science is concerned, until they are reported. The important factors for science are the consistency and accuracy of the reports. In this connection the author also makes an effective attack on S S. Stevens' doctrine of the discriminatory response as an attempt to avoid the subjective, showing that Stevens' doctrine is really self-contradictory. The initial data of all science are private or direct experience.

The problem of inference is reserved for the fifth chapter entitled *Psychological Physiology*. The author first points out that nearly all psychological concepts are ambiguous and that in addition the factors of reification and infiltration cause further mischief. The former is the tendency to regard concepts as things. Contrast, for example, is not a thing but a concept that refers to various combinations of colors and settings. This factor is now playing an important rôle in personality theory with respect to concepts of types and traits. Infiltration is the tendency for meanings to seep into concepts from various sources, especially from explanatory hypotheses. Yet the gaps in knowledge must be filled by hypotheses, even though scientific imagination must be held in restraint especially with regard to the animistic trends of dynamic psychology. The first restraint is to tie inferences to concrete data, while the second is that explanatory concepts must be referred to the organism as it links the sensory and behavioral processes. Various objections to physiological explanations have been advanced, such as the cry that such a procedure is materialistic or mechanistic. The author's answer to this is that such an objection is merely prejudice. The second objection is that we know more about psychological material than about the supposed physiological foundations, and we should accordingly devote our time to the further extension of psychological knowledge. The answer to this is that such an extension gives only a descriptive psychology, and only physiology can furnish an explanatory reference frame, the facts of sensation and reflex having already found a place. The third objection is that explanations are unnecessary and should be replaced by observed correlation, to which the author replies that the correlations we now have are inadequate and explanations based on them are merely guesses. He contends that such a position would eliminate many stimulating hypotheses. The last objection is that the explanations are more mythology than physiology as they are merely constructions. The author's answer is that all scientific explanations are logical constructions, illustrating his contention by a discussion of Sherrington's work on the properties of the synapse. The observed events are called material properties and the explanations formal properties. Science is interested primarily in the latter, and psychologists have used procedures similar to those of Sherrington as in the deduction of the blind spot and in the work on mnemonic traces. These answers appear to the reviewer to be quite adequate with the possible exception of the third, inasmuch as the addition of physiological unknowns does not add to his explanations. Possibly a sounder position might be that the ultimate correlations may be psycho-physiological, but at any rate it is clearly shown by the author that the physiological cannot be left out.

The last chapter is entitled *The Mystery of Mind,* with further emphasis on such topics as the importance of formal properties, the circularity of explanations, and the difficulty of establishing causal relations in psychology, especially of the higher mental processes. In addition, there is a discussion of prediction, particularly with regard to applied psychology. As the author points out, prediction has no logical status from the standpoint of operationism and logical empiricism. It is meaningless for the latter, as it deals with events that do not yet exist. To get around this difficulty the author suggests a scale of probability for projecting the past into the future. This suggestion does not avoid the fact, however, that all the laws of nature rest on the assumption that nature will continue as uniform and with the same uniformity as in the past. On the basis of this assumption the author's view of propositions in psychology having more or less probability value appears to be justified. He points out that this value is especially low in the more complicated forms of behavior, as so many of the important psycho-physiological variables are inaccessible. Applied psychology, accordingly, is largely speculative and unreliable. It is suggested that success in the professions, for example, depends upon knowledge, continuing enthusiasm and interest, and a pleasing personality, of which only the first can be significantly influenced. In teaching there are two more factors: a desire to teach and the ability to communicate knowledge. Especially important here is the author's contention that a knowledge of the subject taught is more important than a study of methods of teaching. This contention may not be popular in schools of education but will obtain the approval of most successful teachers. The attack on applied psychology with the plea for retirement into laboratories and libraries may seem too severe, but the author has deliberately exaggerated in order to emphasize that we cannot expect too much from this field. On the other hand, especially in the field of advertising, much valuable work is being done in applied psychology.

It may be true that Professor Pratt has not established his main thesis of the unity of mental and physical, but the work as a whole is a valuable contribution to a sophisticated analysis of the logical foundations of psychology. The science is no longer afraid of considering philosophical principles. Such a maturity would have prevented a naïve movement like behaviorism with its arbitrary exclusion of data, which has probably caused more harm than good by discouraging abler talent and forcing them into other sciences or philosophy.

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